BASIC GAS CHLORINATION WORKSHOP

1977

Ministry of the Environment

Ontario

The Honourable
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Minister

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INTRODUCTION

The Basic Gas Chlorination Workshop Manual has been prepared as a home study and reference text for treatment plant operators. It includes the information needed by an operator to safely operate and maintain a gas chlorination system employing the variable vacuum gas chlorinator.

The workshop based on this manual is a working course which includes considerable hands-on training using actual equipment. For successful completion of the workshop, the trainee must achieve a passing grade of 70% in written and hands-on testing.

The Training and Certification Section wishes to acknowledge the assistance and contributions of various manufacturers, suppliers, and individuals in the preparation of this manual.

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TOPIC: 1

CHLORINE AND CHLORINATION

OBJECTIVES:

The trainee will be able to

1. Recall the main purpose of chlorination.

2. Explain the disinfection process when chlorine is the agent.

3. Recall other uses of chlorination in water and wastewater treatment operations.

4. Recall the properties of chlorine.

5. Recall the standards set by the Ministry of the Environment Technical Bulletin 65-W-4 Chlorination of Potable Water Supplies.

6. Define
   a) chlorine dosage
   b) chlorine demand
   c) chlorine residual
   and explain their relationship.

7. Calculate
   a) chlorine dosage
   b) chlorine demand
   c) average chlorine dosage per day

GENERAL

Chlorination may be performed at a water or wastewater treatment plant for many purposes but the most important is *disinfection* of the plant effluent. When effluents are discharged to bodies of water or water distribution systems, treatment for the destruction of bacteria and viruses is required to minimize the health hazards. Such treatment is known as *disinfection*. The amount of chlorine necessary to obtain a satisfactory reduction of bacteria will vary greatly with the composition of the influent and/or the degree of treatment the plant provides. The selection of the appropriate disinfection procedures is based on the results of bacteriological tests and other evaluations of the total system.

PROPERTIES OF CHLORINE

Chlorine is a greenish-yellow gas with a penetrating and characteristic odour. It is 2½ times heavier than air, and one volume of liquid chlorine equals 450 volumes of chlorine gas. It can be compressed into a liquid which has a clear, amber colour. At $-35^{\circ}C$ it has zero vapour pressure. However, as the temperature rises so does the vapour pressure and at $20^{\circ}C$ it is 82 psi gauge pressure. This characteristic has to be considered when

1. feeding chlorine gas from a cylinder,
2. dealing with a leaking cylinder.

Chlorine has a high coefficient of expansion. For example, a temperature rise of $25^{\circ}C$ (from $-5^{\circ}C$ to $20^{\circ}C$) will increase the volume by approximately 85 per cent. Such an expansion could easily rupture a cylinder or line if it is full of liquid chlorine. This is the reason for the regulation that all chlorine containers must not be filled to more than 85% of their volume.

Chlorine by itself is non-flammable and non-explosive, but it will support combustion.

TABLE 1-1

PROPERTIES OF CHLORINE
Greenish-Yellow Colour
Heavier than Air
High Rate of Expansion
Moderately Soluble in Water
Non-Flammable and Non-Explosive
Supports Combustion at High Temperature

Chlorine does not kill bacteria and viruses directly but, when chlorine gas and water are mixed together in the chlorinator, hypochlorous acid a strong oxidizing or disinfecting agent is formed.

Chlorine is a surface-active agent and there is a reasonable chance that bacteria hidden within solid particles will not be killed by chlorine. For this reason, chlorine is added for disinfection purposes at a point *after* solids removal. In water treatment, turbidity removal is important because *bacteria can be concealed within the turbidity particles and be inaccessable to the effects of chlorination.*

REACTION OF CHLORINE

Chlorine is an extremely active chemical that will react with many compounds to produce many different products. Such reactions complicate the disinfection process because the chlorine demand of these materials must be satisfied as well as those associated with the disinfection reactions. The quantity of both organic and inorganic substances in the influent varies from place to

place and from time to time, so the amount of chlorine to be added will also vary. Sufficient time (contact time) must be allowed so that there is complete reaction of the chlorine with the chemical and bacterial pollutants as chlorine is added to water or wastewater. The reactions proceed generally as follows:

1. If chlorine is added, it will first react rapidly with reducing compounds such as hydrogen sulphide and ferrous iron. No disinfection results.

2. As more chlorine enters solution, it will react with the organic matter present to form chloro-organic compounds, which will have a slight disinfecting action.

3. Chlorine added in excess of that required by Steps 1 and 2 will react with ammonia and other nitrogenous compounds to produce *chloramines*.

The chlorine used by these organic and inorganic substances (Steps 1 and 2) is known as the chlorine demand.

The chlorine used by ammonia and the nitrogenous compounds is known as the combined residual (Step 3).

The combined residual (chloramines) has a disinfection capability but is slow acting and requires a long retention time. To reduce retention time and increase disinfection efficiency, chlorine in excess of that required in Steps 1, 2, and 3 above can be added. This will destroy most of the chloramines (Step 3) depending on the amount added. *If chlorine is in excess of that required to destroy the chloramines, it forms hypochlorous acid or hypochlorite ions. This is known as free residual chlorine.*

Total Residual Chlorine is combined residual plus free residual.

Chlorine dosage is chlorine demand plus total residual chlorine.

<u>Combined vs. Free Residual</u>

Whether combined or free residual chlorination is practiced depends on a number of considerations.

1. In water treatment:

   a) Combined residual chlorine is the method of choice when

      i) long contact time is afforded

      ii) high and enduring residuals are desirable

      iii) control of algae, aftergrowths and red water in the distribution system is necessary

      iv) chlorine taste and odour must be prevented or minimized.

   b) Free residual chlorine is the method of choice when

      i) water quality is poor

      ii) short contact times exist

      iii) there are high concentrations of iron manganese and colour

      iv) difficult tastes and odours must be minimized.

2. In wastewater treatment, combined residual chlorination is normally the method of choice because the excessively high chlorine dosage required to provide a free residual is uneconomical.

In Summary:

The amount and type of chlorine residual used is controlled by:

1. *degree of chemical and bacterial pollution,*
2. *contact time in the plant beginning with the application of chlorine until the moment it reaches the first consumer or receiving body of water. For effective disinfection, always add chlorine at a point where complete mixing will occur. A minimum contact time of 15 minutes is recommended.*

CHLORINATION OF WATER SUPPLIES

Purpose

While the principal purpose for chlorinating water supplies is disinfection, it serves other purposes:

1. Control of taste and odour problems when free or combined residual chlorination is practised. If too little chlorine is added, the taste and odour problems may become severe.
2. Oxidation of manganese, nitrites, and ammonia, or the destruction of phenols and the removal of algae and slime growth.

Ministry of the Environment Chlorination Objectives

The Ministry of the Environment (Bulletin 65-W-4) has set minimum objectives to be used by treatment plants for chlorination of public water supplies. These objectives are set up on the broadest concept to protect the maximum number of consumers at any one time. Occasionally these minimum objectives will have to be *exceeded* in water plant operating practice and a higher residual may have to be used. A copy of the Bulletin is at Appendix A.

An operator can follow the guidelines in meeting the minimum objectives, but still produce a water contaminated with coliform bacteria. In these cases, public health is in danger. Immediate changes in the chlorination program must be made, such as:

1. increase the chlorine residual,
2. change the type of residual,
3. change the point or points of application,
4. increase the contact time between point of application and the first consumer.

The water utility is an industry and certain quality control measures are required. One of these is the chlorine residual analyser and recorder (See Topic 5). This equipment must be kept in proper operating order. The record of chlorine residual provides the operator with positive proof of the degree of performance.

The chlorine residual must be checked and recorded at least once every 8-hour shift. The residual is always maintained at or above the minimum required for the plant. See Para 3.1 of Appendix A for recommended chlorine residuals.

Topics 10 and 11 Chlorine Testing Procedures describe in detail the equipment and procedure for carrying out residual tests.

pH and its Effect on Chlorination

The pH of a water is an indication of its acidity or alkalinity. It can be lowered to corrosive levels by the addition of chlorine, alum and other coagulants. In some cases, the pH of the raw water may already be too low. Regardless of the cause of low pH, it should be corrected to prevent corrosion by adding an appropriate alkali before the water goes to the distribution system.

All chlorine compounds are most effective in bacteria and virus destruction at low pH. Any pH correction upwards (above 7.5) should be done *after* the chlorine has done its work.

CHLORINATION OF WASTEWATER

Purposes

There are numerous reasons for chlorination other than disinfection at a sewage treatment plant. Difficulty arises however since most plants, unless they are very large, are not equipped to apply chlorine at different locations. One should be aware of the possible uses since chlorine is effective in correcting certain problem situations.

Mechanical sewage treatment plants are required to have chlorination facilities including a chlorine contact chamber. All plant or unit by-passes should be directed to the contact chamber in order to provide some reduction in coliforms prior to discharge. The chlorine residual in the contact chamber discharge should be maintained at 0.5 mg/l during periods of required chlorination. Year round chlorination is required at all plants, except in cases where there is no existing or potential impairment of water used for public consumption. If a case can be established, exemption from chlorination for the winter months November 15 to May 15th only, may be authorized by the Ministry.

Odour Control

Odours in sewage treatment plants that are due to an anaerobic condition will usually respond to chlorination. In most cases the problem is to find the best point of application for the chlorine. In the case of primary clarifiers where the sewage has become anaerobic during the sedimentation period, the chlorine should be added to the incoming sewage. (Prechlorination). When the odour develops

in the sewers due to a low velocity, the chlorine should be added far enough up the sewer so that it has adequate time to control the anaerobic condition before the sewage reaches the treatment facility.

Industrial wastes with high oxygen demand such as those from packing houses, canneries, milk plants, etc., will turn anaerobic very rapidly and if this type of waste is found to be causing odours it should be chlorinated before it enters the sewer.

In controlling odours it is not necessary to chlorinate to a residual. It has been found that a dosage of 40-60 per cent of the chlorine demand will give satisfactory control.

Aid to Sedimentation

Chlorination of raw sewage will improve the rate of settling in primary clarifiers. This is especially true when the sewage is anaerobic as it destroys the gas forming organisms and prevents the sludge from rising.

BOD Removal

Chlorine reduces the BOD of sewage in two ways. Some of the decomposable matter is oxidized by the chlorine, resulting in a permanent BOD removal. Other compounds combine with the chlorine to form chloro compounds, some of which are toxic to bacteria and others are no longer broken down by bacteria. The BOD reduction will vary from 15-35 per cent depending on the condition of the sewage. Generally speaking, the lowest reduction is obtained in fresh sewage and the highest in anaerobic sewage. A BOD reduction of 2 mg/l for 1 mg/l of chlorine is obtained up to the point where a chlorine residual is obtained. Beyond this point the rate of oxidation drops off.

Grease Removal

Chlorination can be used ahead of a clarifier as an aid in grease removal. The chlorine will break the grease emulsions allowing the grease to collect in larger particles that are easier to remove by skimming.

Activated Sludge

There are a number of ways that chlorine can be used to advantage in operating an activated sludge plant. In some cases sludge bulking can be controlled by chlorinating the return sludge. This will require about 5 mg/l of chlorine and should be continued until a satisfactory sludge index is obtained. Sometimes at the start of this treatment the effluent becomes quite turbid, but this condition should clear within a day.

When waste sludge that is being returned to the primary clarifier tends to float, chlorination of this sludge will give better settling.

When an activated sludge plant is overloaded, there are several points in the plant where chlorine can be added to reduce the load. It can be used ahead of the primary clarifier to reduce BOD and increase the amount of solids settled, or it can be added to the aeration channels to aid in oxidation. When added to the final clarifier, it can be used to control biological activity and prevent flotation of the sludge. The best point at which to add the chlorine can only be determined by experience and varies from plant to plant.

When a plant has become anaerobic from breakdown or overloading, chlorination is the quickest way to return it to an aerobic condition. In this case, the addition of chloride of lime is more effective than chlorine gas, as the pH is always low when a plant is anaerobic, and the lime raises the pH while the chlorine corrects the anaerobic condition. Care should be taken that the pH is not raised to the point where calcium carbonate is precipitated as it tends to form scale on the diffusers and plug them.

Supernatant liquor from digesters may cause a higher oxygen demand on the activated sludge process than can be dealt with by normal chlorination methods. Due to the high chlorine demand of this liquor, dosages as high as 80 mg/l or more may be necessary to give adequate control.

Some success has also been attained in cleaning air diffusers by feeding chlorine gas into the diffuser headers.

Sludge Thickening

In some plants, sludges, both activated or primary, are thickened before they are pumped to the digester or dewatered. Chlorine can be used here to control bacterial action and better settling and concentration is obtained. To do this it is necessary to maintain a residual of 1 ppm of chlorine in the supernatant liquor above the sludge.

Breakdown of Concrete and Mortar

The hydrogen sulphide that develops in anaerobic sewage can cause other problems besides odour. This gas is quite soluble in water and will dissolve in moisture that has condensed on the walls and roof of a sewer. It is then oxidized by the air in the sewer to sulphuric acid and will dissolve the cement from the concrete and mortar and allow them to crumble. Chlorine, of course, is the answer to this problem, as it will oxidize the hydrogen sulphide before it condenses on the surface of the concrete and will also control the organisms that produce the gas.

CHLORINE DOSAGES

Appendices B, C, D are copies of W & T Bulletins listing chlorine dosages for water supplies, swimming pools and the treatment of sewage. Application of these dosage figures should be governed by MOE guidelines at Appendix A.

Dosage Calculations

It is very necessary for a plant operator to know how to calculate the dosages of the various chemicals used in water and wastewater treatment. It is important to be accurate when figuring the dosage as too little chemical may be ineffective and too great a dosage a waste of money. As a result, for process control the exact dose of chemical to be added must be determined for the purpose of efficient operation of equipment and for economic considerations.

When a plant is designed to treat a particular water supply or wastewater influent, preliminary laboratory tests are carried out to determine the chlorine demand. Knowing the specified combined and/or free residual required from Bulletin (Appendix A) the chlorine dosage is calculated. Chlorine Demand + Chlorine Residual = Chlorine Dosage.

The chlorination equipment is then selected to permit 50% greater dosage than the maximum anticipated. On start up, this predetermined feed rate is applied. Subsequent testing for combined/free residual provides the information which indicates whether this feed rate must be adjusted. The operator must be able to calculate feed rates based on daily flow rates and test results once the plant is in operation.

EXAMPLE 1:

In designing a plant, the chlorine demand of an effluent as determined by testing is 15 mg/l. How many pounds of chlorine per day will be required to treat a flow of 4.5 MGD (million gallons per day) when a total chlorine residual of 0.5 mg/l is required?

Total Dosage = Chlorine Demand + Chlorine Residual

= 15 + 0.5 = 15.5

In this question it will be necessary to utilize our knowledge of mg/l to pounds conversions.

$$15.5 \text{ mg/l} = \frac{15.5 \text{ lbs } Cl_2}{1,000,000 \text{ lbs}}$$

$\therefore$ for every 1,000,000 lbs. of water to flow through we will need to use 15.5 lbs. of chlorine.

If the flow is 4.5 MGD and we know 1 gallon weighs 10 lbs. we have 45 million lbs. of water flowing through per day.

$$4.5 \times 10^6 \text{ gals} \times 10 \text{ lbs} = 45 \times 10^6 \text{ lbs}$$

$\therefore$ for 45 million lbs. flow we will use

$$45 \times 10^6 \text{ lbs/day} \times \frac{15.5 \text{ lbs } Cl_2}{10^6 \text{ lbs}} = 697.5 \text{ lbs } Cl_2\text{/day}$$

EXAMPLE 2

At 8:00 a.m. on Tuesday the chlorine cylinder scale indicated 232 lbs. and the water meter read 78,343,000 Imp. gals. At 8:00 a.m. on Wednesday the chlorine cylinder scale indicated 169 lbs. and the water meter read 85,763,000 Imp. gals. What was the average chlorine dosage in mg/l during this 24-hour period?

Chlorine used during 24-hour period = 232 - 169 = 63 lbs.
Water treated during same period

85,763,000 - 78,343,000 = 7,420,000 gals.

Average chlorine dosage:

$$\frac{63 \text{ lbs (chlorine)} \times 1,000,000}{7,420,000 \text{ Imp. gals. (water)} \times 10 \text{ (factor to convert gals. to lbs.)}} = 0.85 \text{ mg/l}$$

A simple formula to remember:

$$\boxed{\frac{C}{\bar{W} \times 10} \times 1{,}000{,}000 = \text{mg/l}}$$

Replace C with no. of lbs. of chlorine.

Replace W with no. of Imp. gals of water.

Remember to use the same time period for both.

EXAMPLE 3

A chlorinator is set at 210 lbs/day. If the average daily flow through the plant is 1.75 MGD, what is the DAILY AVERAGE CHLORINE DOSAGE IN mg/l?

We must convert lbs/day dosage to mg/l dosage.

We are told we use 210 lbs. chlorine for every 1.75 million gallons water or 17.5 million lbs. water (1 gal = 10 lbs).

$$\frac{210 \text{ lbs/day Cl}}{(1.75 \text{ MGD})(10 \text{ lbs/gal}) \text{ Flow}} = \frac{210 \text{ lbs/day Cl}}{17.5 \text{ M lbs/day Flow}}$$

$$= \frac{12 \text{ lbs Cl}}{1 \text{ million lbs/day}} = \underline{\underline{12 \text{ mg/l}}}$$

Above we divided pounds of chlorine used per day by the flow (in pounds) and found we used 12 lbs. chlorine for every million pounds flow or 12 mg/l.

EXAMPLE 4

In a water treatment plant with a flow rate of 1.75 MGD the required total chlorine residual is 0.5 mg/l. In testing, the operator determines that his total chlorine residual is 4.5 x mg/l when the dosage rate is 12 mg/l. What should be the correct feed rate?

Measured Total Residual	4.5 mg/l
Required Total Residual	0.5 mg/l
Excess Residual	4.0 mg/l

or

4 lbs per 1,000,000 lbs water

Flow rate 1.75 MGD

$$\text{Excess chlorine used} = \frac{1.75 \times \cancel{10^6}\ \cancel{\text{gal}}}{\text{day}} \times \frac{4\ \cancel{\text{lb}}}{\cancel{10^6}\ \cancel{\text{lb}}} \times \frac{10\ \text{lb}}{\cancel{\text{gal}}}$$

$$= 70\ \frac{\text{lb}}{\text{day}}$$

12 mg/l is a dosage of 210 lbs/day (See Example 3).

$\therefore$ Correct feed rate should be 140 lbs/day.

APPENDIX A

O N T A R I O

MINISTRY OF THE ENVIRONMENT

CHLORINATION OF POTABLE WATER SUPPLIES

Technical Bulletin 65-W-4

Revised September, 1973

CHLORINATION OF POTABLE WATER SUPPLIES

I N D E X

1.0 INTRODUCTION

1.1 Purpose of Bulletin

To provide a minimum standard of design and operation of chlorination facilities. New installations should meet the criteria as set out in the bulletin and existing facilities are to be brought up to standard in a reasonable length of time.

1.2 When Disinfection Required

Treatment by continuous and adequate disinfection is required when the supply is obtained from a surface source; when the supply is exposed to contamination during treatment; when ground water sources are or may become contaminated, as in fractured limestone areas; or where local conditions, such as flooding, indicate the need.

2.0 EQUIPMENT

2.1 Capacity

Chlorination equipment shall have a maximum feed capacity at least 50 per cent greater than the highest expected dosage required to provide a free chlorine residual. In addition each gas chlorinator not supported by additional standby units of equal capacity shall have a conversion kit sized to double the capacity of the machine.

2.2 Chlorinators and Controls

Dependable feed equipment, either of the gas feed or positive displacement solution feed type, shall be used for adding chlorine. Automatic proportioning of the chlorine dosage to the rate of flow of the water treated shall be provided at large plants and at all plants where the rate of flow varies without manual adjustment, or operation, of valves and/or switches.

2.3 Duplicate Equipment

Chlorine feed equipment at plants providing chlorination to ensure the safety of the supply shall be installed in duplicate, to provide uninterrupted operation of equipment during times of breakdown. In addition, spare parts consisting of at least the commonly expendable parts such as glassware, rubber fittings, hose clamps, and gaskets, should be provided for effecting emergency repairs.

For a multi-well supply system requiring chlorination for disinfection, the standby requirement may be met by one portable unit.

2.4 Weigh Scale

When gas feed chlorinators are employed, a set of corrosion resistant scales should be made available for weighing the chlorine cylinders serving each operating chlorinator.

2.5 Hypochlorite Solution

Where a powdered product is used, hypochlorite solutions shall be prepared in a separate tank. The solution is allowed to clarify before it is directed to the solution storage tank serving the hypochlorinator.

2.6 Safety Equipment (Gas application only)

Each plant shall have readily available, a self-contained or air-supplied type of respiratory protective equipment. Smaller installations may make arrangements with a local fire department or other agency for the loan of the required equipment on an emergency basis with a canister type mask being located at the plant.

When a canister type mask is used in place of a self-contained or air-supplied unit the operators must be made fully aware of its limitations and the location of the more adequate equipment.

One respirator shall be immediately available, located in a conspicuous location outside the area of probable contamination.

Protective clothing including gloves, goggles and safety shoes shall be available for persons handling chlorine.

Eye wash fountains shall be available in case of accident.

Preferably weigh scales for 150 pound cylinders shall be recessed in the floor

Safety chains shall be used to retain 150 pound cylinders, either in storage or on weigh scales, in a safe upright position.

2.7 Building Detail (Gas application only)

Gas chlorine equipment - chlorinators, weigh scales, chlorine cylinders - must be located in an isolated building, room or rooms. In larger installations the storage and scale facilities should be in a room separated from the chlorinators. The construction of the room or rooms should be of fire resistant material and have concrete floors.

Ton cylinders shall be stored on their sides on level racks, between four and eight inches off the grade. Chlorine should not be stored below ground level and the cylinders must be protected from excessive heat, dampness, and mechanical damage.

Areas containing chlorine or chlorinator equipment shall be clearly marked "DANGER! CHLORINE STORAGE" or "DANGER! CHLORINE FEED EQUIPMENT" as applicable.

The exit doors shall be hinged to open outwardly. There shall be two or more exits if the distance of travel to the nearest exit exceeds 15 feet. In each case, one door should be on an outside wall.

Continuous mechanical ventilation at the rate of three air changes per hour shall be provided, or screened openings to the outdoors shall be provided within six inches of the floor in the ratio of one square foot per 500 square feet of floor area. Similar openings shall be provided in or near the ceiling. The openings shall be distributed to produce the maximum air circulation across the floor. Secondly, provision for emergency mechanical ventilation should be made sufficient to produce 30 air changes an hour taking suction at a maximum of three feet above floor level.

Th temperature in the storage and scale room shall not be higher, and preferably slightly lower, than that in the chlorinator room. The gas lines between the scales, chlorinators and injectors shall not be located on an outside wall or in a location where low temperatures may be encountered.

2.8 Testing Equipment

All installations must be equipped with a permanent standard chlorine residual comparator test kit. When free residual chlorination is mandatory an amperometric titrator is also required.

In larger installations, or where poor raw water quality and/or minimum supervision indicates a hazard, an automatic residual analyzer and recorder is required. The chlorine residual recorder shall be equipped with a low residual alarm and installed to measure the chlorine residual in the water leaving the plant.

3.0 ROUTINE OPERATION

3.1 Chlorine Residual

For complete water treatment plants which effect both pre- and post-chlorination, or when a minimum of two hours contact time is assured before distribution after the application of chlorine, or for ground or protected surface water supplies, proven to be materially free from bacterial and viral contamination, the minimum chlorine residual shall be 0.2 mg/l. For all other water supplies the minimum chlorine residual shall be 0.5 mg/l.

The chlorine residual test is performed on a sample of the plant or pipe line-effluent, after it has been held for 15 minutes.

When ground water sources are proven to be free from possible viral and/or bacterial contamination they may be exempted from chlorination.

As circumstances demand the minimum requirements for chlorine residual may be increased.

A free residual chlorination program may be made mandatory, depending on the source of supply and treatment works, and it is a preferred method of treatment.

It is suggested that a chlorine residual be maintained in all active parts of the distribution system.

The selection of appropriate disinfection procedures are contingent upon the results of bacteriological and other evaluations on the total water system including the source of supply.

3.2 Chlorine Application Points

Where possible pre- and post-chlorination shall be practised. When only post-chlorination is possible free residual chlorination should be considered, and a minimum contact time of 15 minutes, before the first possible consumer, shall be provided at all times.

3.3 Chlorine Residual Test

The following procedure shall be followed in performing the orthotolidine chlorine residual test.

1. Draw sample of chlorinated water. The tap should be kept running continuously or for a few minutes before taking the sample.

2. Allow sample to stand for 15 minutes to simulate the required minimum contact period.

3. Use 0.5 ml of orthotolidine (O.T.) reagent in 10 ml cells, 0.75 in 15 ml cells, and five ml in 100 ml tubes. Place reagent in testing tube; add sample to required volume; and mix. When the temperature of the sample is less than 68°F bring it to that temperature quickly after mixing with the O.T.

4. A colour comparison is made when the maximum colour develops.

5. The test results are recorded in the plant records and any necessary alteration is made to the chlorine application rate.

The above procedure is satisfactory for determining the total available chlorine residual. When the free residual is required the sample must be near 32°F when the O.T. is added and the colour comparison is made immediately. The orthotolidine-arsenite (O.T.A.) test can also be used to determine the free available chlorine residual.

The accuracy of an automatic chlorine residual analyser shall be checked daily. This is accomplished using either the amperometric titration or orthotolidine colourimetric test procedures. The results of the check are inscribed on the recording chart along with the date and operator's initials, opposite a mark showing the time of the check.

The chlorine residual test must be performed frequently enough to ensure that an adequate chlorine residual is maintained at all times. Such points as raw water quality and a resultant variation in chlorine demand, and changing flow rates must be taken into consideration. When a residual analyser alarm system is used the testing frequency may be reduced.

3.4 Records

Minimum records shall include:

1. daily records of the chlorine used and scale readings,
2. results from all chlorine residual tests,
3. the flow rate and chlorine feed rate at the time of testing,
4. water used and chlorine dosage in mg/l on a daily basis,
5. detail on chlorine cylinder changes, orders and chlorine on hand, and
6. monthly and yearly summaries of chlorine consumption and feed rates.

4.0 EMERGENCY OPERATION

Where chlorination is required for disinfection purposes a continuous feed of chlorine must be assured. For this type of service the operating authority shall develop a standby operating procedure to cover emergencies. The procedures developed shall be posted in a prominent location in the plant and all operators shall be made aware of the information thus given.

The emergency information shall include:

1. the order not to pump unchlorinated or inadequately chlorinated water to the distribution system,

2. the name, address and telephone number of -
   (a) senior supervisory personnel,
   (b) medical officer of health,
   (c) Ontario Ministry of the Environment,
   (d) chlorinator service company, and
   (e) chlorine supplier,

3. the order to notify the Ministry of the Environment, and the medical officer of health immediately if unchlorinated or inadequately chlorinated water is directed to the distribution system,

4. details on emergency chlorination procedures,

5. a statement on operator responsibility, and

6. details on announcing a "Boil Water Order" (developed with MOH).

When emergency chlorination is provided the chlorine residual in the water leaving the plant shall be 1.5 mg/l.

When unchlorinated or inadequately chlorinated water has been directed to the distribution system, and until direction is obtained from the Ontario Ministry of the Environment, the chlorine feed rate shall be increased and a program of hydrant flushing initiated to provide a chlorine residual of 1.0+ mg/l in the whole of the distribution system. When increasing the chlorine residual or carrying out an extensive hydrant flushing program, notify all customers who may be adversely affected.

5.0 ADVERSE BACTERIOLOGICAL RESULTS

When the results from bacteriological samples collected from the distribution system do not meet the requirements of the Ontario Ministry of the Environment Drinking Water Objectives, the Ontario Ministry of the Environment and the local medical officer of health shall be notified. The Ministry will recommend corrective action suited to the individual circumstances. The recommendation may include one or a number of the following procedures:

(a) the disinfection, for a 24-hour period, of the distribution system with a solution having a starting strength of 50 mg/l of available chlorine;

(b) the initiation of chlorination procedures on an unchlorinated supply;

(c) an increased chlorine residual requirement together with a distribution system flushing and/or swabbing program;

(d) the collection of further samples;

(e) a recommendation to the medical officer of health that a "Boil Water Order" be issued.

6.0 DISINFECTION OF NEW WORKS

6.1 Preparation

Before disinfection is attempted, all surfaces must be thoroughly cleaned. Pipe lines are flushed with potable water until a "turbidity-free" water is obtained at all ends. Where possible foam swabs should be used to assist cleaning. Reservoirs are to be brushed as required, to obtain clean surfaces, and disinfected as per AWWA Standard D 102-64 or equivalent.

As chlorine is a surface active disinfectant it may not penetrate crevices or particles of debris. Therefore, a thorough cleaning is necessary if the disinfection program is to be effective.

6.2 Disinfection

Disinfection may be accomplished by one of the following procedures.

1. In mains all surfaces shall be in contact, for a period of 24 hours, with a chlorine solution having a starting strength of 50 mg/l. If a residual of less than 25 mg/l remains at the end of the contact period the procedure shall be repeated.

2. In large mains a "slug method" may be used, whereby a slug of water containing at least 300 mg/l of available chlorine is moved through the pipe at a rate such that the chlorine is in contact with the pipe for at least 3 hours.

3. To conserve water and chemical, reservoirs may be disinfected by spraying all surfaces with a chlorine solution havin a starting strength of 250 mg/l available chlorine. Special protective clothing and self-contained or air-supplied type respirator must be used by personnel performing the spray procedure and necessary safety precautions adheared to.

4. When surface conditions are not ideal, such as will be encountered in used works, special disinfection procedures will be required. This could include the maintenance of a chlorine residual for an extended period of time.

6.3 Testing

After disinfection, and when the chlorine residual in the treated works is at or below the normal operating level, bacteriological samples shall be collected. When a 0.2 mg/l or greater available chlorine residual is to be maintained in or after the new works, one set of satisfactory bacteriological results shall be obtained before the system is placed into operation. Otherwise, a minimum of two sets of coliform-free results shall be obtained before the works are placed in service.

APPENDIX B

chlorine dosages for the treatment of water

PURPOSE OF CHLORINATION	DOSAGE IN PPM[1]	CONTACT TIME IN MINUTES	RECOMMENDED RESIDUAL TYPE	PPM
Disinfection: With Combined Residual[2] With Free Residual[3]	 1.0-5.0 1.0-10.0	Requirements determined by local health authorities		
Ammonia (NH_3-N) Removal	10xNH_3-N content	20+	Free	0.1
Taste & Odor Control	10xNH_3-N content plus 1-5 ppm	20+	Free	1.0
Hydrogen Sulfide (H_2S) Removal	2.22xS content to free sulfur 8.9xS content to sulfate	Instantaneous	Free or combined	0.1
Iron (Fe) Removal[4]	0.64xFe content	Instantaneous	Combined	0.1
Manganese (Mn) Removal[4]	1.3xMn content	Variable	Free	0.5
Red Water Prevention	Maintain a free residual in dead ends	Variable	Free	0.1
COLOR REDUCTION	1.0-10.0	15	Free or combined	0.1
Algae Control	1.0-10.0	Variable	Free	0.5+
Slime Control	1.0-10.0	Residual needed throughout system	Free	0.5+
Control of Iron and Sulfur Bacteria	1.0-10.0		Free	1.0+
Coagulation Aid for Preparation of: Activated Silica Chlorinated Copperas	 1.56 lb. per gal. 41 Baumé Na_2SiO_3 1 part per 7.8 parts $FeSO_4 \cdot 7H_2O$	Not Applicable		

Combined residual means the residual produced by the reaction of chlorine with the natural or added ammonia, or with certain organic nitrogen compounds.

Free residual means the residual produced after the destruction with chlorine of ammonia, or of certain organic nitrogen compounds.

Filtration is also required.

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APPENDIX C

chlorine dosages for the treatment of sewage

PURPOSE OF CHLORINATION	DOSAGE IN PPM	RECOMMENDED RESIDUAL IN PPM
Disinfection of:		
Fresh Raw Sewage	6-12	
Septic Raw Sewage	12-25	
Fresh Settled Sewage	5-10	Requirements usually
Septic Settled Sewage	12-40	determined by local
Chemical Precipitation Effluent	3-10	health authorities
Trickling Filter Effluent	3-10	or state regulations.
Activated Sludge Effluent	2-8	
Sand Filter Effluent	1-5	
Odor Control:		
Up Sewer	1.5-10	0
At Plant	5-10	0
Activated Sludge Operation:		
Sludge Bulking Control	2-8	0
Sludge Thickening	Variable	1.0
Trickling Filter Operation:		
Odor Control	2-6	0
Filter Pooling	5-40	1.0-2.0
Filter Fly Control	3-10	0.1
B.O.D. Reduction	6-12	0.2-0.5
Imhoff Tank Foaming	3-15	0
Digestor Supernatant	20-80	0-trace

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APPENDIX D

chlorine dosages for the treatment of swimming pool water

The chlorine dosage requirements of swimming pool waters are dependent on the type and magnitude of the chlorine residual required. This is usually governed by regulatory health authorities.

The conditions which affect the chlorine requirements include continuity of recirculation, rate of recirculation, efficiency of filtration, the number and location of the pool inlets for filtered water, the bathing load, the type and shape of the pool, the type of chlorine residual produced, pH and alkalinity.

The dosage rate can be based either on pool capacity or on the recirculation rate. Both methods of calculation are used very extensively.

The recirculation rate can be obtained by noting the pump capacity or by multiplying the capacity of the pool by 3, where the turn-over rate is three times in 24 hours; or by 4, where the turn-over rate is four times in 24 hours; or by any other turn-over rate that may be in use in any particular instance.

The usual chlorine dosages, unless otherwise directed by local health regulations, are as follows:

TYPE OF POOL	CHLORINE APPLICATION BASED ON RECIRCULATION RATE	
	Average Minimum	Average Maximum
Indoor	2.0 p p m	5.0 p p m
Outdoor	3.0 p p m	10.0 p p m

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SUBJECT: 2

CHLORINATION EQUIPMENT

TOPIC: 2

GAS CHLORINATION
SYSTEM INSTALLATION

OBJECTIVES:

The trainee will be able to

1. Name the basic types of chlorine feeders and recall their uses.

2. Identify the major components of a typical gas chlorination installation and the purpose of each.

3. Describe the correct method(s) for venting gas feed equipment

   a) when one chlorinator is used

   b) when more than one chlorinator is used

   c) when the chlorinators are of different sizes and types.

GAS CHLORINATION INSTALLATION

CHLORINE FEEDERS

The three basic types of chlorine feeders (or chlorinators) and their uses are:

1. *Dry* (direct) *feed* gas chlorinators are used to apply dry chlorine gas to sewage. They are used only where water under pressure is not available. Their use requires care in selecting the point of application.

2. *Solution feed* gas chlorinators are used to mix an auxiliary supply of water with chlorine gas. The mixture or solution is then applied to the water or the sewage to be treated. Vacuum-type chlorinators are the most preferred.

3. *Hypochlorinators* are used:

   a) for relatively low flows,

   b) where chlorine gas cannot be fed for safety reasons,

   c) where the chlorine requirement is small.

   Installation costs are lower than for gas chlorinators, but operating costs are higher. Generally, hypochlorinators are diaphragm-type pumps. Attached for information at Appendix A is a short discussion of hypochlorination.

Since this workshop manual deals principally with gas chlorination, the following paragraphs describe a typical gas dispenser installation (See Figure 2-1).

Chlorinator

Figure 2-1 depicts a variable feed vacuum gas chlorinator, the description and method of operation being dealt with in Topic 4. It should not be installed too close to the wall as the operator must have access to the rear of the chlorinator.

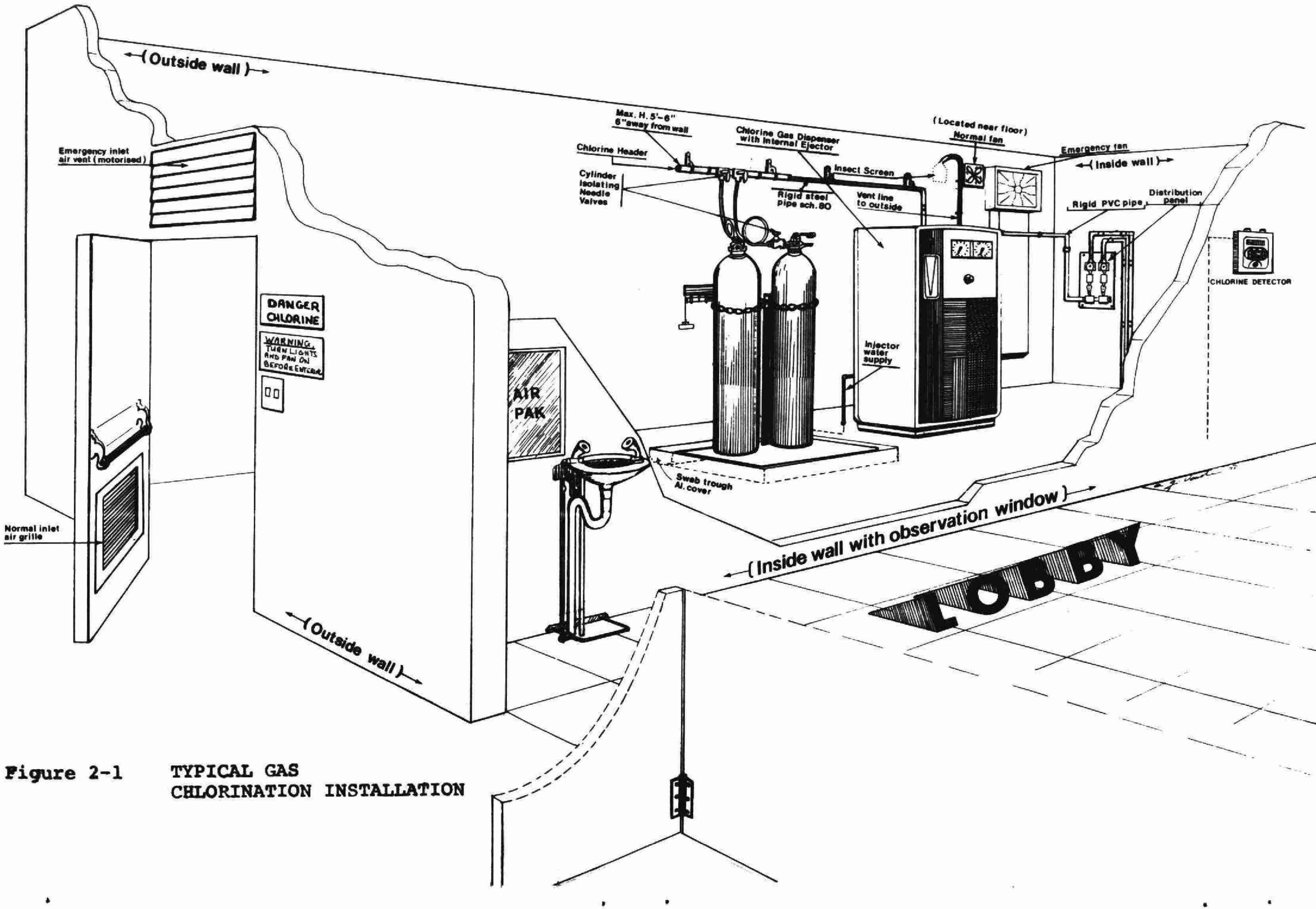


Figure 2-1 TYPICAL GAS CHLORINATION INSTALLATION

Chlorine Gas Cylinder(s)

Chlorine gas is shipped from the supplier to the water or wastewater treatment plant in 150-lb. cylinders, one-ton cylinders and in tank cars. The type of container used will depend on the amount ordered and shipped. Topic 3 discusses storage and handling of chlorine.

Chlorine Weighing Scales

The only reliable method of determining the contents of a cylinder is by weighing. The types of scales used in the water and wastewater treatment industry are beam scales, dial scales, and special types of scales.

1. *Beam Scales* are the most common type used in smaller water and sewage treatment plants. Beam scales have a knife-edge type of platform. The weight to be measured is placed on the platform and determined by moving a counter-weight along the beam until the beam is balanced.

2. *Dial Scales* usually have the same type of knife-edge platform as beam scales, but the wieght to be measured is indicated directly on the dial. Dial scales are used extensively to measure the amount of chlorine in ton cylinders.

3. *Special Types of Scales* include: electronic, loss of weight recorders, transmitters for remote reading and/or recording, 150-lb. container scales.

Flexible Coils (or Pigtails)

Flexible coils are used to connect the cylinder valve (or the cylinder) to the manifold or header valve. They allow movement of the cylinder on the weigh scales, and allow easy connecting and disconnecting of the cylinder.

NOTE:

1. *Do NOT make any sharp bends or kinks in the flexible coils.*
   WHY? (a) to prevent blockage in line
   (b) to prevent possible break in line.

2. *When connecting or disconnecting the coil and the cylinder, always use the two wrenches designed for that purpose.*
   WHY? (a) to hold the flexible coil and prevent twisting
   (b) to prevent breaking of flexible coil off cylinder or header.

Chlorine Manifold or Header

The chlorine manifold or header is the section of SOLID piping between the chlorinator and cylinder(s) through which the chlorine gas passes from the cylinder(s) to the chlorinator. The flexible coils from individual cylinders are connected to it. Valves should be installed at each flexible connection to permit isolation of a cylinder from the system.

Booster Pump

Some chlorine installations may not have sufficient water pressure at the injector to form a vacuum. A booster pump may be needed to provide the necessary pressure to overcome friction losses and meet the pressure demands of the system. It should be located in a room separate from the chlorinator.

Water Pressure Regulator

This unit is used to control and maintain the water pressure at a constant value and eliminate fluctuations caused by the increase or decrease of the pressure. The installation and use of a water pressure regulator can also prevent excessive wear on the injector throat and tailway and cut down on the noise caused by water flowing at very high pressures.

The required water pressure and flow will vary with the amount of chlorine added, and also with the size of the injector.

Strainer Preceding the Injector

It is recommended that a strainer be installed on the water line to the injector. This prevents any possible grit or foreign material from entering and blocking the injector, or causing undue wear on the injector throat and tailway.

If a booster pump is used in the system, the strainer should precede the pump (the injector comes after the pump). A "Y" type strainer is used for ease of cleaning.

The size of screen opening would depend on the size of the injector throat, as well as the foreign materials suspended in the water.

Valves (Excluding Chlorinator Valves)

1. Cylinder Valve
   Used to open or close individual cylinders.

2. Auxiliary Valve
   At the end of flexible coil connecting to the cylinder. If the coil is left disconnected from the cylinder, the auxiliary valve must be closed. This prevents corrosion caused by any moisture accumulation in the coil. (See Figure 2-2)

3. Header or Manifold Valve
   The header valve connects the flexible coil to the fixed piping, or cylinder header. It is used to isolate individual cylinders from the chlorination system. Its construction is similar to the cylinder valve, except that the header valve does not have a fusible plug.

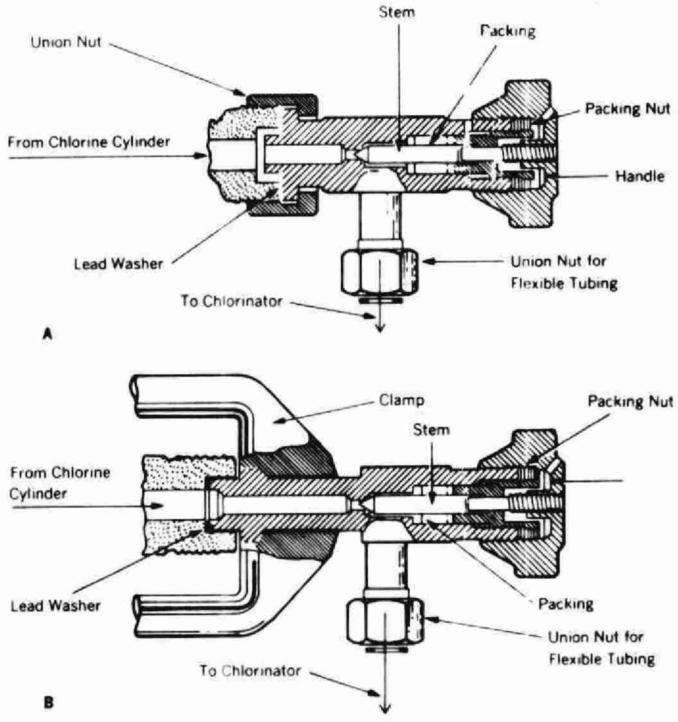


Figure 2-2 AUXILIARY CYLINDER VALVE
A. SCREW IN TYPE
B. CLAMPED TYPE

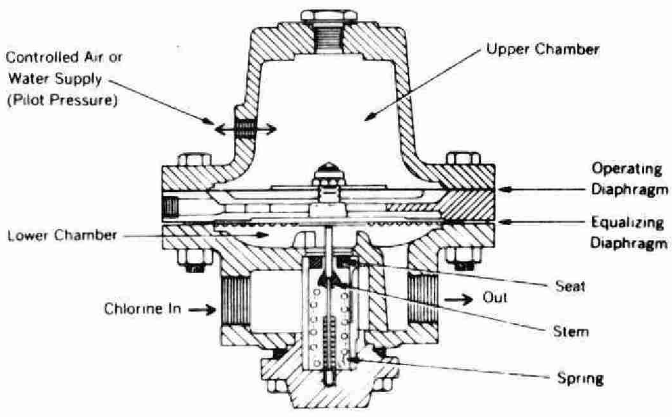


Figure 2-3 CHLORINE PRESSURE REGULATING VALVE
PILOT OPERATED (AIR OR WATER)

4. <u>Check Valve</u>
   Used to prevent any solution from returning or flowing back into the water line.

5. <u>Relief Valve</u>
   Installed in the water line between the booster pump and the chlorinator to prevent any excessive build-up of pressure.

6. **<u>Pressure Regulating Valve (PRV) in Header</u>**
   Used primarily to prevent chlorine gas from changing to liquid chlorine in the line between the cylinders and the chlorinator. The PRV also helps to control the chlorine gas pressure into the chlorinator. It should be located as close to the cylinder as possible. (See Figure 2-3)

<u>Exhaust Fan</u>

An exhaust fan is installed in the chlorination room to prevent any accumulation of chlorine gas and to provide a specific number of air changes according to the Ministry of Labour Code. It is usually mounted near the floor level on the outside wall of the building. In some cases, the fan is mounted high on the wall or on the roof with an inlet duct going down to within 18 inches of the floor level. The duct vent must be near floor level.

The louvers and blades on the fan should be inspected regularly to ensure trouble-free operation (See Start-Up, Topic 7).

The exhaust fan switch should be located on the outside wall near the door to the chlorine room.

<u>Vent Line</u>

In many water treatment plants, more than one type of gas is used, the most common being chlorine and sulphur dioxide or chlorine and ammonia. Since these gases are not

compatible, it is necessary to protect the gas feeding equipment, by eliminating common vent lines. If one machine is drawing from atmosphere and another is discharging to atmosphere at the same time through a common vent line, the discharged gas will be drawn into the other machine. Results would be drastic to internal parts of the equipment and to the interior of the vent line.

Where two chlorinators of different basic characteristics are hooked to a common vent line, it is quite possible for one which has the gas shut off to draw chlorine through the venting system of the other. Where an old style "water diaphragm" chlorinator (bell jar type) and a new style mechanical diaphragm are connected to a common venting system, the greater volume in the mechanical diaphragm equipment can draw water out of the old style machine through the vent line and into the mechanical diaphragm equipment. This will result in severe damage to vent lines and internal parts of the equipment.

Separate vent lines must be used when:

1. more than one type of gas is in use,
2. using one type of gas, but machines of different characteristics, size, or manufacture.

APPENDIX A

HYPOCHLORINATION

The chemical reactions and analyses are the same as for the solution feed gas chlorinators.

Hypochlorinator is used when gas chlorination is not feasible because:

1. Low flows make initial cost of gas equipment uneconomical
2. Hydro-power not available (see Water Operated Hypochlorinators)
3. Shipping facilities for chlorine cylinders are not feasible
4. Location makes chlorine gas too dangerous for storage and use
5. Where less than 4 lbs/day of chlorine (not solution) are required.

FORMS OF HYPOCHLORITE

Powder

The powder is shipped in 50 or 100 lb. drums and has up to 70% available chlorine.

Hypochlorite Solution

A saturated solution of chlorine and water (approximately 13%) is shipped in plastic 5 gallon containers. It is usually diluted with water before use to one per cent solution.

DANGERS OF HYPOCHLORITE

Powder

1. Protective equipment for skin, eyes and respiratory tract is required to prevent dust from affecting the operator. As this dust has a large percentage of chlorine, moisture in the skin helps to form strong hydrochloric acid, burning and damaging body tissue.
2. Clothing should be protected. Powder (when wetted) becomes a powerful bleach.
3. Contents of drum must be kept dry and covered to prevent powder from hardening, and chlorine fumes from entering the atmosphere.

Solution

1. Protection for skin, eyes and clothing is required because of possible spills and splashes.
2. All containers must be kept covered to prevent evaporation and the release of fumes to the atmosphere.

HANDLING

Covered plastic containers are to be used for mixing and storing solutions, **as the solution will corrode most metals.**

Mixing of powders must be done with as little dusting as possible. Water should be put in the container and powder added - *do not add water to powder.* Initial mixing should be done with container on a stand, so that after the solution has settled for 24 hours, the liquid can be syphoned off into a second container, leaving the residue in the first container for disposal.

Under no circumstances should the suction of the hypochlorinator be allowed to draw any residue from the bottom of the container. This will block up the system.

NOTE: When using sodium or calcium hypochlorite, scale often builds up in the tubing and chemical pump. This is a combination of the chlorine carrier base and minerals from the water in the container being precipitated out by the action of the chlorine. If this causes problems (blocking of solution lines, pump body, etc.), the addition of 1 tablespoon of a water softener (such as Calgon) per 10 gallons of water before chlorine is introduced, will greatly reduce precipitation.

The strength of the solution can be adjusted to the requirements of the particular installation.

CHLORINE SOLUTION

May be used direct from container if strength is less than 15% chlorine. Most new chemical pumps will handle this, but a number of the older types of pumps could not exceed a maximum strength recommendation of 5%. *Check with the pump manufacturer if in doubt.*

If the solution is to be diluted, add it to the required amount of water. Again, if the water is very hard, add the softener first if necessary.

NOTE:

1. *All powder or solution should be covered and stored in a cool dry area away from direct sunlight (sunlight and heat will cause the chlorine to be released to the atmosphere as a gas.*
2. *All spills of powder, solution, or mixed solution should be flushed away with copious amounts of water as soon as possible to prevent fumes and damage to other equipment in the room.*

HYPOCHLORINATORS (pumping equipment)

The types of pumps employed as hypochlorinators are:

1. Diaphragm
2. Peristaltic
3. Piston

Diaphragm Pumps

The diaphragm type is the most common in this particular field. It usually consists of a plastic pump head with a plastic or rubber diaphragm and ball or poppet valves. These pumps are usually good for pressures up to 100 psi.

Many manufacturers are supplying these pumps in sizes ranging from 500 GPD down; motors may be internal or external, depending on the manufacture and the model. Relatively few maintenance problems are involved, provided equipment is kept clean and no leaks of solution are allowed.

Peristaltic Pump

Peristaltic pumps generally consist of a piece of soft resilient plastic tubing around a circular core. Two rollers rotate around the core, driving the liquid ahead of the rollers and into the system. These pumps are not recommended for application against pressures of more than 5 psi, and delivery rates are limited.

Maintenance problems on this type of pump usually involve leaking, collapse of the tube, or improper pressure of the rollers.

Piston Pump

Piston pumps are similar to diaphragm pumps. These can be used at much higher pressures such as is usual in industrial processes.

PUMP CLEANING PROCEDURES

Periodic cleaning of all these pumps is relatively simple.

1. Shut off pump.
2. Disconnect from point of application.
3. Remove suction line from container.
4. Insert both suction and discharge lines into a 5% muriatic acid solution.
5. Start pump and allow to run until no foam can be seen coming from the discharge.
6. Replace suction tube into container, reconnect discharge line to system and operate.

The point where the solution is introduced to the water system (Point of Application) is especially liable to a build-up of residue. When installing the unit, provide for easy removal to facilitate cleaning.

CONTROL OF ELECTRICALLY OPERATED HYPOCHLORINATORS

These pumps are usually connected electrically with the main pumping systems to stop and start at the same time as the main pump. The stroke length or pump speed on the hypochlorinator is then used to control the residual dosage.

On some of the more sophisticated systems, the speed can be varied on the pump motor to control the hypochlorite flow to meet changing demands. The residual can be controlled by an electric or pneumatic positioner attached to the stroke length adjustment.

Peristaltic pumps do not have a stroke length adjustment and therefore have only one possible control.

WATER OPERATED HYPOCHLORINATORS

Another interesting type of hypochlorinator which receives fairly wide usage is the water operated type. This pump has a plastic solution head with plastic (usually hypalon) diaphragm and poppet valves, but requires no electrical power. It will pump hypochlorite solution in direct proportion to the flow of water through a water meter.

A section is added under the dial unit of the meter which gives a side take-off shaft to control a cam on the hypochlorinator. As this shaft turns, it closes a water valve in the hypochlorinator, and water pressure builds up behind a power diaphragm. This moves the pump shaft ahead and discharges solution from the hypochlorinator. When the cam releases, the water pressure is discharged from the power diaphragm and a spring returns the pump shaft to its original position, drawing more solution into the pump head.

Since the action of the pump shaft depends on the speed of the water meter shaft, the chlorine addition is in proportion to the flow and the residual is controlled by manually adjusting the stroke length and/or the solution strength.

This system allows treatment in remote, unmanned stations where electric power is not available. It is limited to flow control only.

On all except the peristaltic pump, the discharge will not be constant due to the recharging cycle of the pump. Therefore, some attention must be given to proper mixing within the water system before reaching the first consumer.

Some of the modern pumps are now being built with a very short recharging cycle, so this problem is not nearly as prevalant as it has been in the past.

SUBJECT: 2

CHLORINATION EQUIPMENT

TOPIC: 3

STORAGE AND HANDLING OF 150 LB. AND 1 TON CYLINDERS

OBJECTIVES:

The trainee will be able to

1. Describe the principle features of 150 lb. and 1 ton cylinders.

2. Recall the methods of handling cylinders.

3. Recall the requirements for storage of cylinders.

4. Recall how to determine the weight of the contents of cylinders.

5. Recall the procedures for and demonstrate how to connect/disconnect cylinders using

   a) clamp and adapter

   b) threaded connections

CHLORINE GAS CYLINDERS

TYPES

Chlorine is shipped in three types of containers, 150-lb. cylinders (the most familiar), one-ton containers and tank cars. The contents of any of these consist of a liquid phase and a gaseous phase.

150-lb. CYLINDERS

Description

CHLORINE CYLINDERS

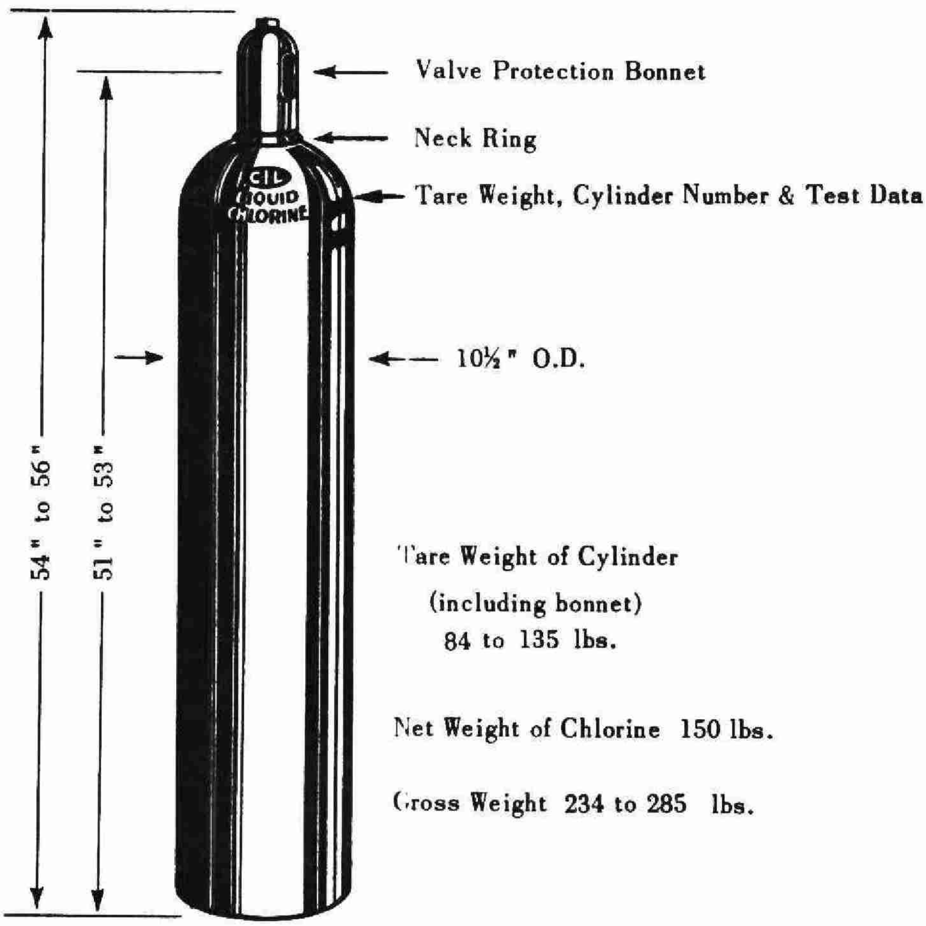


Figure 3-1 CHLORINE CYLINDERS

Chlorine cylinders (Figure 3-1) are of seamless steel construction and each is equipped with an approved type of valve. Every cylinder is fitted with a bonnet designed to protect the valve from impact due to knocking or dropping.

Letters and numbers are stamped on each cylinder indicating ownership, specification, cylinder number, tare weight and dates of hydrostatic tests. *It is illegal to deface these markings in any way.*

The 150-lb. cylinders are equipped with a single Chlorine Institute standard cylinder valve which has a brass body and a Monel stem. There is a packing gland containing two rings of packing and a fusible plug. Valves are tested and reconditioned or renewed by the manufacturer after each trip. The fusible plug is made of poured metal and located on the side of the valve opposite the outlet. The fusible plug will melt at a temperature of 70°C. Its purpose is to release chlorine if pressure becomes excessive due to fire or over-heating. (Refer to Figure 3-2)

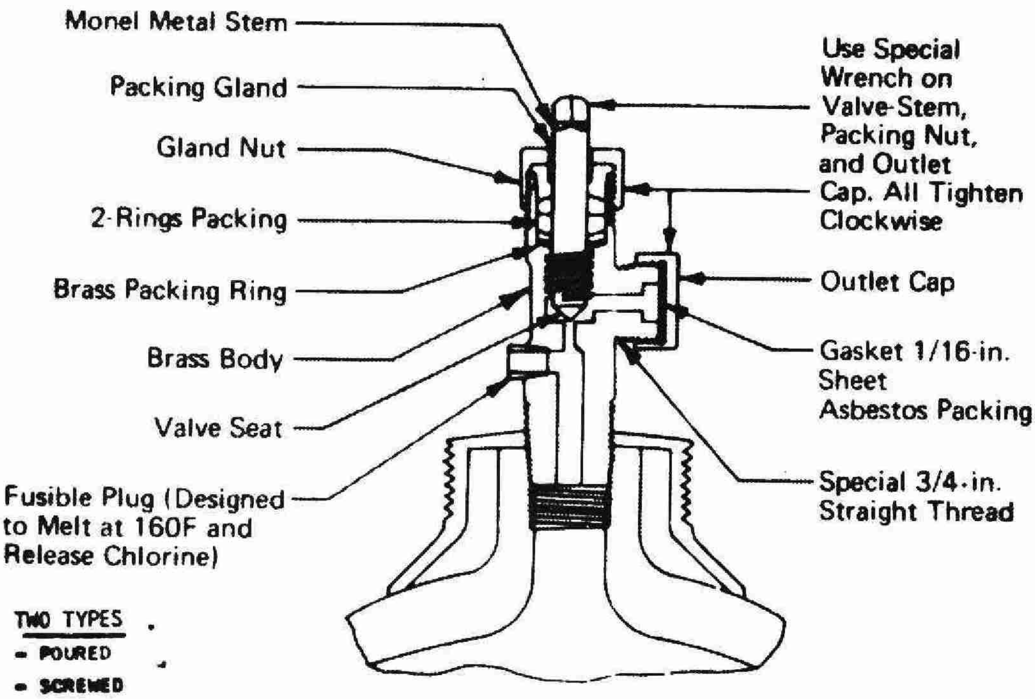


Figure 3-2 CHLORINE INSTITUTE STANDARD CYLINDER VALVE

150-lb. cylinders are normally used in a vertical position for gas withdrawal.

DO NOT RE-USE WASHERS. ALWAYS USE A NEW WASHER.

NEVER LIFT CYLINDER BY THE BONNET.

The protective hood on the 150-lb. cylinders is screwed onto a threaded neck ring. Despite its appearance, the neck ring is actually not part of the cylinder, and is often not securely attached to the cylinder.

ALWAYS KEEP THE HOOD IN PLACE EXCEPT WHEN CYLINDER IS IN USE.

Handling

When unloading and moving full 150-lb. cylinders, do not allow them to be dropped from the truck, and prevent them from falling over or against each other. When moving cylinders, use a light three-wheeled hand truck with rubber tires with a clamping arrangement or safety chain at least two-thirds of the way up the cylinder. Whenever possible, two men should be present when moving or changing cylinders. The same care should be used in handling full and empty cylinders.

Experienced operators can safely move a cylinder by rolling it on its bottom edge, but do not let it get out of control and fall, and do not allow the protective bonnet to turn loose. The protective bonnet should be in position and removed only when the cylinder is being connected to the chlorinating system. Chlorine cylinders should be used only for transporting and storing chlorine.

To lift a cylinder when an elevator is not available, use a crane or hoist with a special cradle. *Chains, rope slings and magnetic devices should never be used for lifting. Never lift a cylinder by the valve-protective bonnet.*
The hood is not designed to carry the weight of the cylinder.

Storage

Chlorine cylinders are stored upright and arranged to allow removal of any cylinder with a minimum handling of the other cylinders. Storage space should be well ventilated, easy to get at and kept at normal room temperature.

If it is impossible to avoid having cylinders stored or used on a floor below ground level, an adequate exhausting system must be provided for removing any escaped gas. Cylinders should be stored in a dry location because a damp atmosphere will corrode the threads of the protective bonnet, making it difficult to remove.

Empty cylinders should be stored in a separate area from full cylinders. Cylinders must be stored in an upright position and prevented from falling over by using a safety chain anchored to the wall with a snap hook and placed around the outside of the cylinders.

Outside storage areas should be sheltered from the direct rays of the sun, or from excess cold. Cylinders should be brought in from the storage area to the chlorine room at least 24 hours before hooking them up to the chlorination system. This allows time for the cylinder temperature to reach room temperature.

CYLINDERS SHOULD *NOT* BE STORED:

1. near combustible or flammable materials such as oil, gasoline and waste
2. on an uneven floor or one covered with debris
3. near the inlet of a ventilating or an air-conditioning unit
4. In sub-surface locations
5. near an elevator shaft
6. near any source of direct heat such as a furnace, heating element or radiator.

Weighing the Cylinder

The only reliable method of determining the contents of a cylinder is by weighing. *The pressure in a cylinder depends upon the temperature,* not upon the amount of chlorine in the container. Where convenient, the cylinder should stand on a scale throughout the entire period of discharge. In any event, the only sure method of determining whether or not the cylinder is empty is to weigh it and check its weight against the tare stamped on the cylinder shoulder.

Cylinder Connection

The standard way of making a connection to the valve is with a yoke clamp, adapter a small lead gasket and auxiliary valve. (See Figure 3-3). These three items are supplied by the chlorine suppliers.

Wear plastic-coated gloves when connecting or changing cylinders. Operators must wear protective goggles when working around chlorine equipment.

When making connections with piping having threaded couplings instead of the yoke type, *two wrenches must be used:* the large spanner for the coupling and the small spanner holding the squared area of the pipe itself at the coupling. Use the flat spanner or box-end wrenches supplied by the manufacturer for all chlorine cylinder pipe connections.

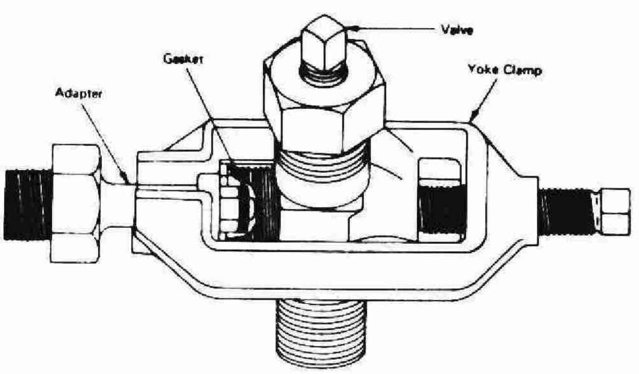


Figure 3-3 VALVE CLAMP AND ADAPTER ASSEMBLY

To connect a cylinder to the chlorinating system using the clamp and adapter, proceed as follows:

1. Secure the cylinder to a building column or solid, upright support;

2. Remove the protective bonnet. If the cylinder has been exposed to the weather for a long time, the threads at the base of the bonnet may have been corroded, in which case a few smart raps on opposite sides of the bonnet will loosen it so it can be unscrewed easily;

3. Remove the brass outlet cap and any foreign matter which may be in the valve outlet recess. Use a two-inch nail to clear out any old washer or pieces of lead in outlet recess;

4. Place a new lead washer in the outlet recess;

5. Soak the yoke, adapter and clamp in kerosene, clean with a wire brush and smear the slide and threaded adjustment screw lightly with a light grease. Inspect the yoke adapter for rounded or worn edges at the contact point of the adapter clamp;

6. Place the clamp over the valve. Insert the adapter in the outlet recess and then, fitting the adapter in the clamp slot, tighten the clamp screw. Make sure the end of the adapter seats firmly against the lead washer. Figure 3-4 shows a cylinder connected to the coil.

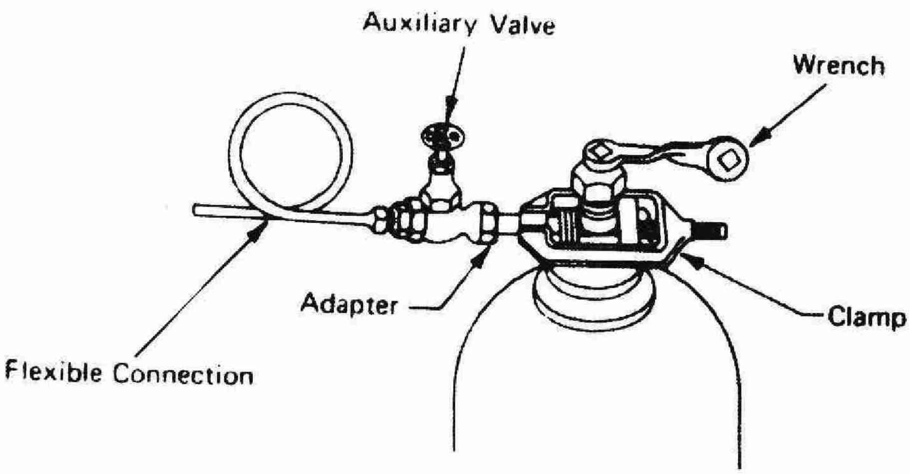


Figure 3-4 CYLINDER CONNECTION

7. The piping from the cylinders to the header located on the wall or to the chlorine machine must have an inverted loop of not less than 10" in diameter in its length. The loop acts as a flexible coupling.

Disconnection

To disconnect a cylinder, having followed the shut down procedure in Topic 7,

1. **Close the cylinder valve;** *Use the wrench provided,* **grasping the valve in one hand and tapping the wrench in a clockwise direction** with the palm of the other. If the valve does not close tightly on the first trial, it should be opened and closed lightly several times until proper seating is obtained. *Never use a hammer or any other tool to close the cylinder valve tightly.*

2. Detach the flexible coil from the cylinger by loosening and removing the clamp. This coil should be supported while the empty cylinder is being replaced by a full one. For example, support it on another cylinder, use a hook, or a stick from the floor (a broom would be handy). This will prevent the development of weak spots in the pipe.

3. If the pipe line is disconnected for any length of time, plug the open end of the pipe using a cloth, and shut the auxiliary valve. There is a danger of moisture forming in the line.

4. Screw the protective bonnet in place as soon as the cylinder is disconnected, so that the valve parts will be protected from the moisture in the air. The outlet cap of each valve is fitted with a gasket which is designed to fit against the valve outlet face. If a valve leaks slightly after closing, the leak may be stopped by drawing up the valve cap tightly. If the gasket

is not in position, an outlet cap may be taken from another cylinder or a suitable gasket may be cut from an asbestos or synthetic rubber sheet. When the valve cap is used to stop a leak, the gland nut should also be well tightened.

ONE-TON CYLINDERS

Description

A one-ton container has two valves, very similar to the one on the 150-lb. container; in fact, the only difference is that these valves do not have a fusible plug. Instead, the ton cylinder has three separate fusible plugs in each end, which will melt at 70^{o}C and discharge the chlorine from within. The delivery rate of chlorine from a ton container will depend on the temperature of the liquid in the container, but an average flow is about 20 pounds per hour of chlorine gas. When the one-ton cylinder is set on the scales, the two discharge valves should be one above the other. The top valve will discharge chlorine gas. **The bottom valve will discharge chlorine liquid. (Refer to Figures 3-5 and 3-6). Figure 3-7 shows a typical one-ton cylinder hook-up.**

Never operate valves in such a manner as to isolate chlorine gas or liquid in a line. In some installations using one-ton cylinders, there is a short length of tubing running between cylinder(s) and evaporator(s). There is a valve on the cylinder and one on the evaporator line. See Figure 6-1 . The tubing between the two is full of liquid chlorine during normal operation. If for some reason the valve on the evaporator line is closed and then the cylinder valve shut, the tubing is left full of liquid chlorine. A small increase in temperature will cause a considerable increase in gas pressure. With the tubing full of chlorine and closed at both ends, there is no room for gas expansion and a potentially dangerous situation exists.

The safe procedure is to close the cylinder valve first and then allow sufficient time for the chlorine in the tubing to be exhausted by the evaporator before closing the evaporator inlet valve. This is the procedure followed when changing cylinders.

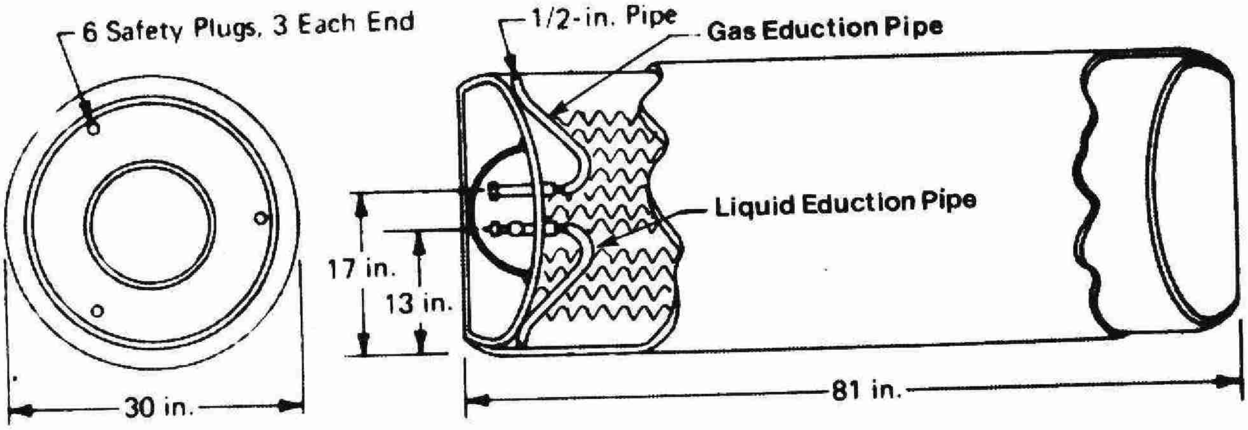


Figure 3-5 CROSS SECTION OF TON CONTAINER

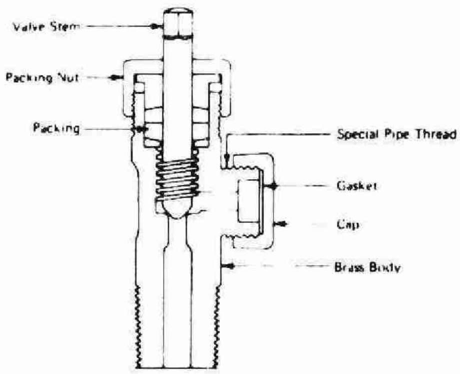


Figure 3-6 TON CONTAINER VALVE

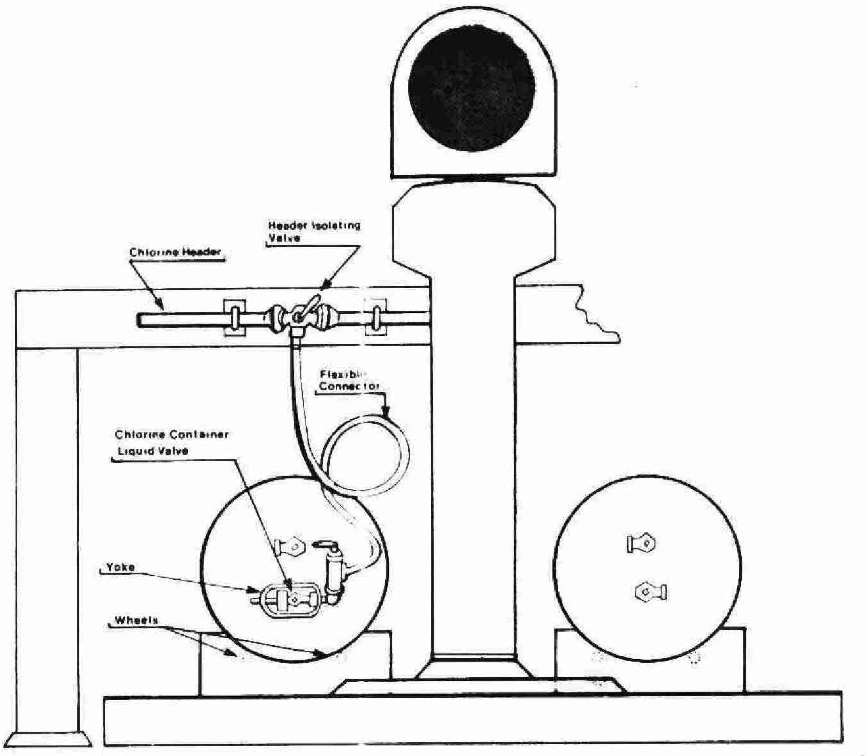


Figure 3-7 TYPICAL ONE-TON CYLINDER HOOK-UP WITH SCALES

Storage and Handling

One-ton cylinders must be moved by an approved lifting bar and hoist, and not by rolling them along the floor.

General storage conditions are the same for both one-ton and 150-lb. cylinders.

Connecting One-Ton Cylinders

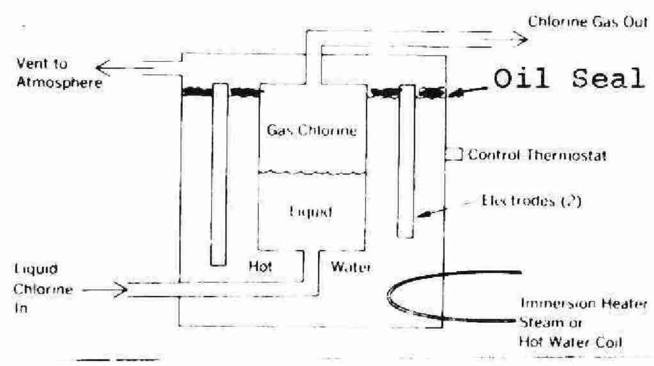
The procedure for connecting one-ton cylinders to header or chlorinator is the same as described for the 150-lb. cylinders, and should be followed accordingly.

Evaporator

An evaporator is used with one-ton containers or tank cars, and not with 150-lb. cylinders. It is also used where large amounts of chlorine gas are required (over 400 lbs/day). It changes liquid chlorine into chlorine gas at a faster rate than is obtained from a container at room temperature. The evaporation rate of liquid chlorine increases with temperature and as more liquid chlorine changes into chlorine gas, the amount of gas available increases.

As indicated in Figure 3-8, liquid chlorine is fed into a chlorine cylinder which is immersed in a bath of hot water. The water is heated by an immersion heater (steam, hot water or electric), and the temperature of the bath is controlled by a thermostat at approximately 70°C. Note in the drawing the slight layer of oil ("oil seal") to prevent evaporation of water.

Figure 3-8
Evaporator



SUBJECT: 2

CHLORINATION EQUIPMENT

TOPIC: 4

DESCRIPTION AND OPERATION OF GAS CHLORINATORS

OBJECTIVES:

The trainee will describe the normal operation of the following chlorination system:

1. Wallace & Tiernan (W&T) variable vacuum chlorinator.
2. Advance Chlorinator.
3. Wallace & Tiernan (W&T) Bell Jar chlorinator.
4. BIF Industries chlorine feeder;
5. Fischer & Porter gas dispenser.

WALLACE AND TIERNAN (W&T) VARIABLE VACUUM CHLORINATOR

COMPONENTS

Figure 4-1 shows a diagram of the W&T Variable Vacuum Chlorinator and its principal components.

Injector/Ejector

The water-operated injector or ejector (Figure 4-2) consists of a venturi-type nozzle and a diaphragm back-flow check valve. Water enters the venturi under high pressure, low velocity. At the "neck" or nozzle, this changes to low pressure, high velocity, thereby creating a partial vacuum. This vacuum draws chlorine gas into the venturi, and the solution of chlorine and water is then discharged to the point of application.

The injector is the first point in the process where the chlorine gas comes into contact with the water. Total mixture of the solution usually occurs at or beyond the injector discharge.

A back-flow check valve (Figure 4-2) connected to the injector is used primarily to prevent any solution from backing up into the chlorine line, leading to possible corrosion of materials.

Should an accident occur while the operation is under proper vacuum, air would be drawn into the chlorinator, thus preventing chlorine from reaching the atmosphere. Negative or low pressure permits the use of lighter, corrosion-resistant plastic components. If chlorine is under any pressure, do not use plastic components.

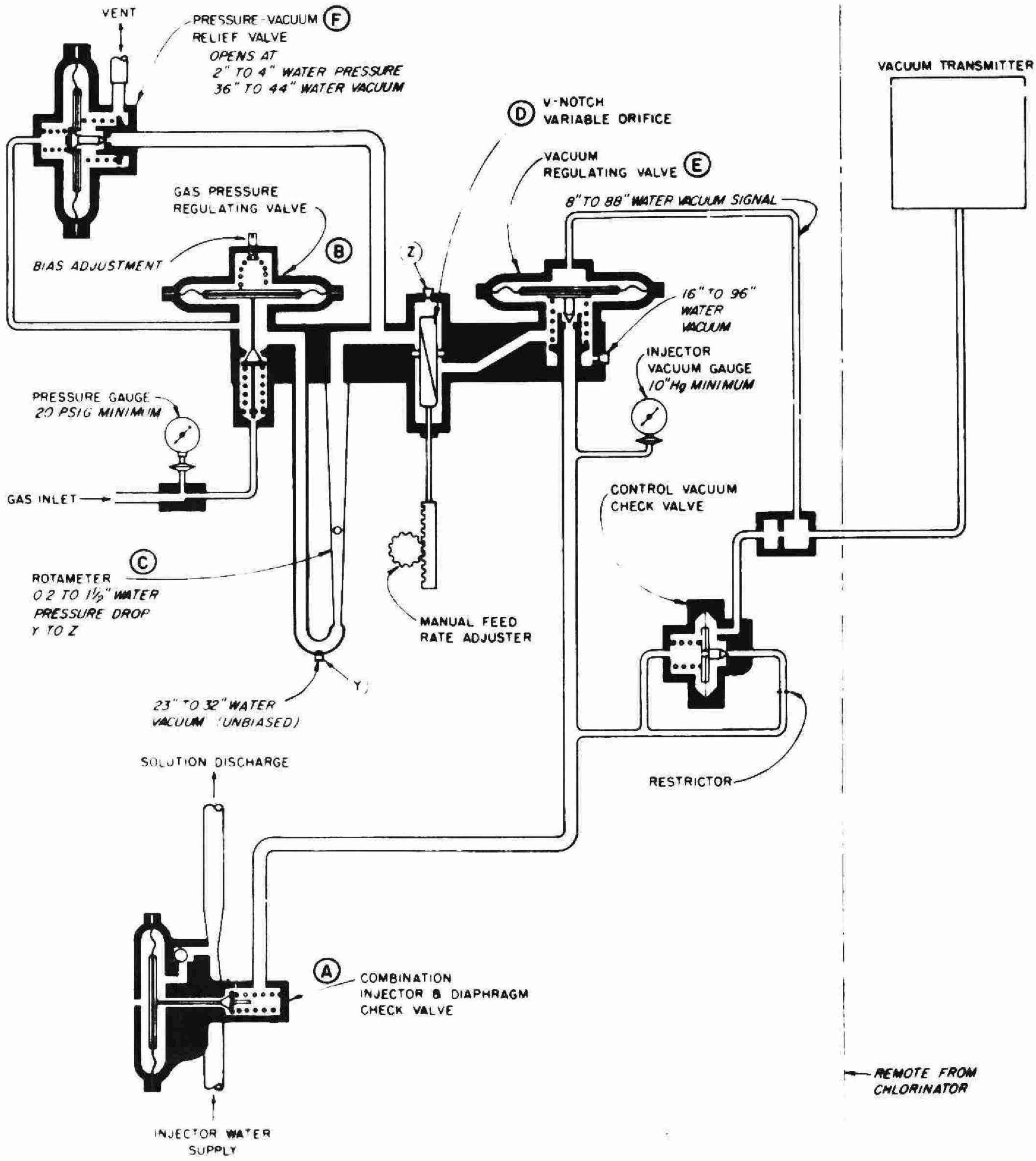


Figure 4-1 W&T VARIABLE VACUUM CHLORINATOR

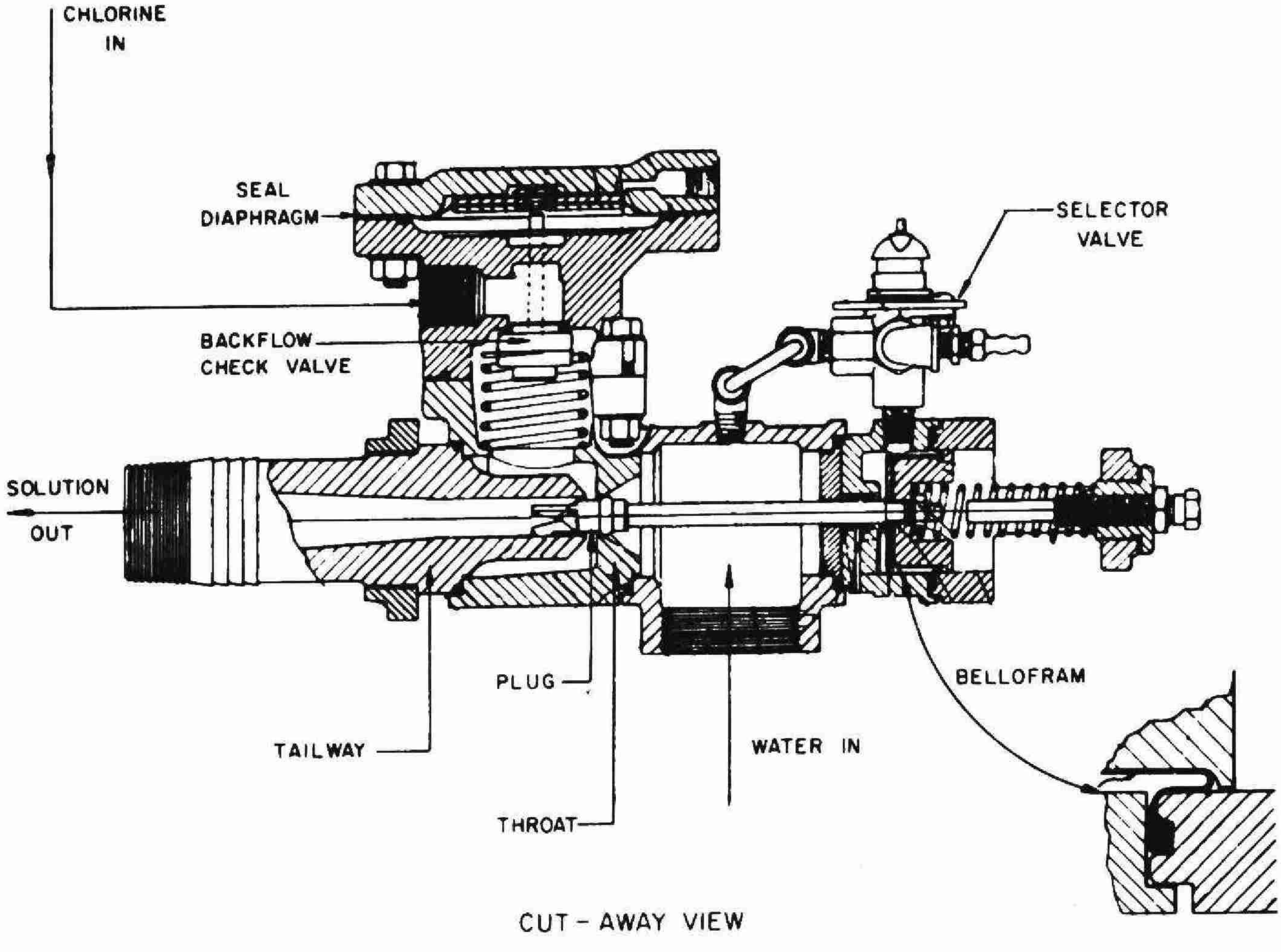


Figure 4-2 INJECTOR

The injector may wear with time. If the raw water contains any foreign matter, a strainer should be installed in the water line to the injector. The injector does NOT have to be installed on the chlorinator but may be located wherever it is convenient.

Chlorine Pressure Regulating Valve (CPRV)

On leaving the header, the gaseous chlorine enters the chlorinator through the CPRV (See Figure 4-3). The CPRV is a diaphragm valve which works against a spring force. It maintains the proper operating vacuum ahead of the variable orifice. The vacuum in the chlorinator must be greater than the spring force in the CPRV to draw chlorine gas into the chlorinator. The vacuum pulls the diaphragm and stem down; chlorine gas flows through the feed rate indicator at the indicated pounds per day setting. The spring force in the CPRV controls absolute pressure (or vacuum) in the regulating valve.

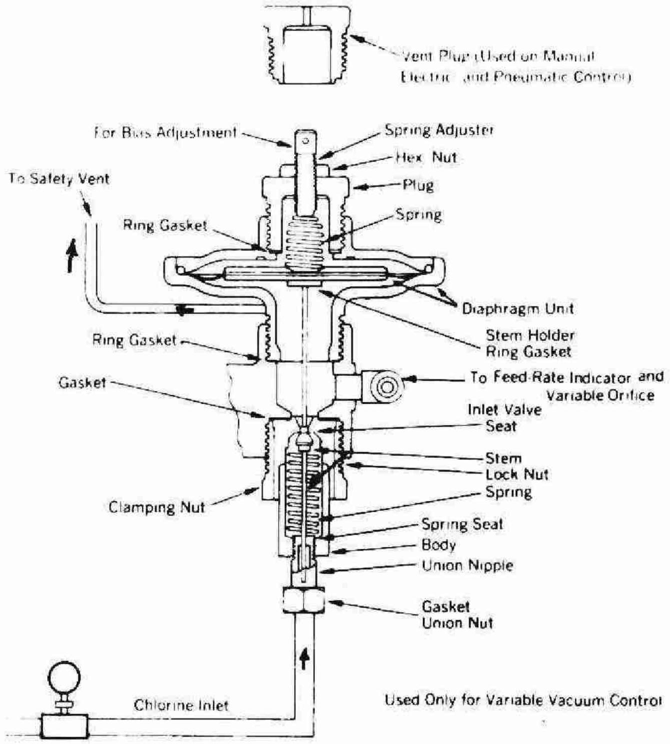


Figure 4-3 CHLORINE PRESSURE REGULATING VALVE

Feed Rate Indicator (or Rotameter)

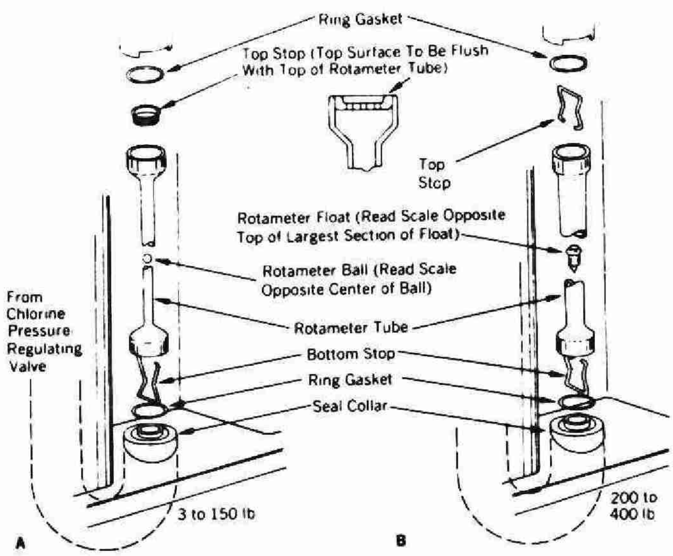


Figure 4-4 ROTAMETER

The feed rate indicator, or rotameter (See Figure 4-4) is a tapered glass tube with a round ball inside. The ball will position itself in the rotameter according to the chlorine gas flow. The size of the glass tube depends on the gas flow required. When operating normally, the ball is free to rotate inside the tube. If it is not rotating, the ball is stuck against the inner walls of the tube because the inner walls are dirty. Use trichlorethylene to clean the rotameter.

Gas flow readings are taken across the centre of the ball, not across the top or the bottom. Other types of floats are also used, and will depend on the size of chlorinator and the gas flow through the unit. The point of reading on a float will depend on the manufacturer. Read his instructions. The feed rate indicator tube and float are pre-determined for a specific maximum capacity and cannot be interchanged. For example, a float from a 10 lb/day maximum capacity rotameter cannot be used in a 20 lb/day maximum capacity tube.

Pressure-Vacuum Relief Valve

The pressure-vacuum relief valve (Figure 4-5) is a diaphragm-operated two-way spring-loaded valve and is used to provide vacuum relief in the chlorinator system or draw air into the chlorinator. It prevents a build-up of vacuum which could damage the unit, and vents chlorine to the atmosphere if there are problems in the chlorine pressure regulating valve.

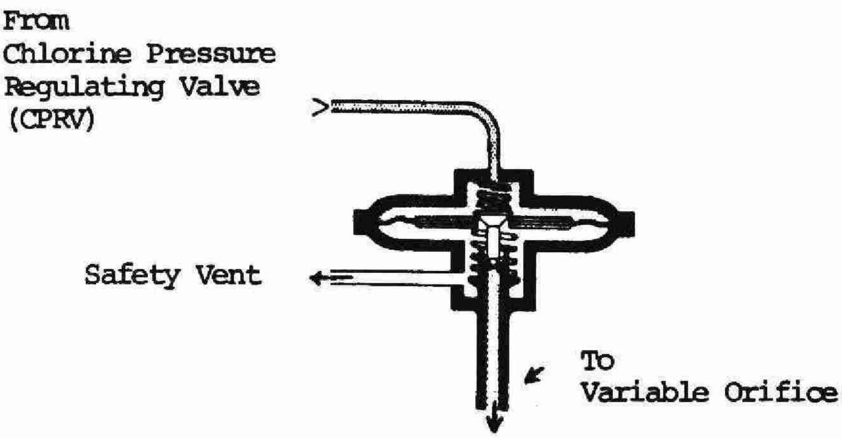


Figure 4-5 PRESSURE VACUUM RELIEF VALVE

Variable Orifice

The variable orifice (Figure 4-6) is the part of the chlorinator which controls the flow of chlorine through the chlorinator. The orifice can be adjusted manually or automatically and its setting will depend on the chlorine demand in the water or wastewater process. There are different types of orifices available, as indicated in Figure 4-6.

Variable Orifice

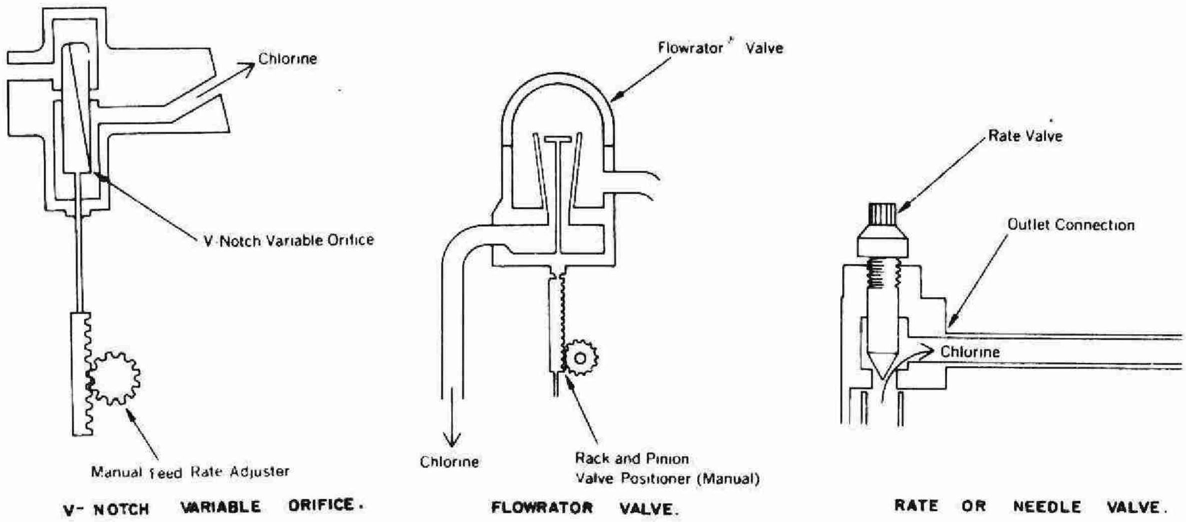


Figure 4-6 TYPES OF VARIABLE ORIFICE CONTROL

Vacuum Regulating Valve

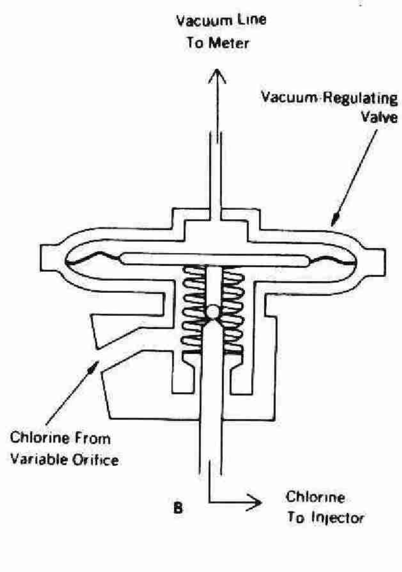
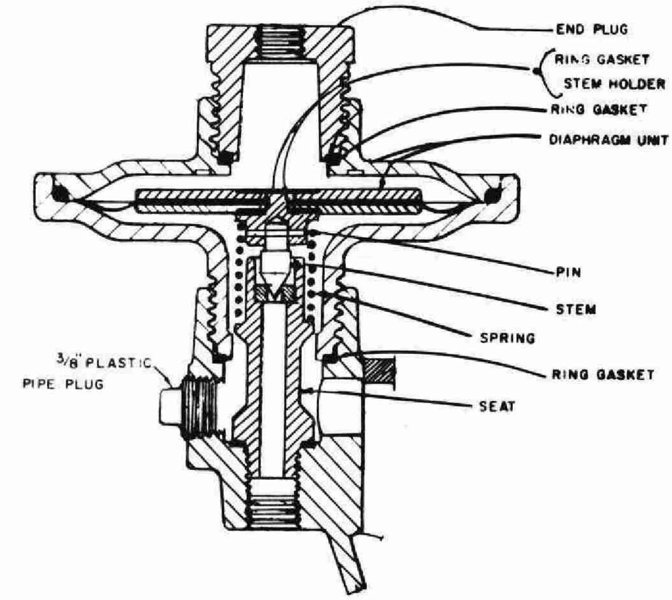


Figure 4-7 VACUUM REGULATING VALVE

The diaphragm, spring-loaded vacuum regulating valve (Figures 4-7 and 4-8) maintains the proper operating vacuum downstream of the variable orifice. Chlorine passes through the vacuum regulating valve to the injector.



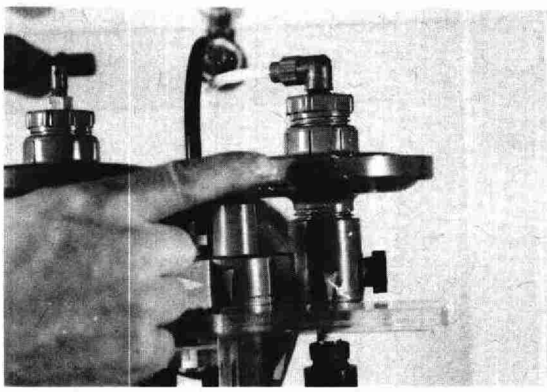


Figure 4-8 VACUUM REGULATING VALVE
400 LB CAPACITY CHLORINATOR

OPERATION (See Figure 4-1)

A controlled vacuum is developed by an injector (A), allowing the chlorine gas to enter the chlorinator through a spring-loaded, diaphragm-operated pressure regulating valve (B). This valve maintains the proper operating vacuum ahead of the variable orifice (D).

The gas then flows through a rate of feed indicator (C), by-passes a combination vacuum and pressure relief valve (F), passes through the variable orifice (D), and finally through a vacuum regulating valve (E), which maintains the proper operating vacuum downstream of the variable orifice.

The gas then passes to the injector (A) where it is dissolved in water. The resultant solution is discharged from the injector to the point of application via a solution tube or diffuser. The feed rate is adjusted by changing the area of the variable orifice. This is accomplished by positioning the control plug (V-notch) within the seat.

The chlorine pressure regulating valve, which regulates the vacuum ahead of the metering orifice, also shuts off the chlorine if interruption of the injector water supply should destroy the operating vacuum, or a leak should develop in the vacuum line. Intermittent start-stop or program operation is obtained by interrupting the injector water supply.

ADVANCE CHLORINATOR

OPERATION

Figure 4-9 illustrates the flow diagram for the Advance Chlorinator. Water passing through the injector under pressure at point (A) forms a vacuum and causes diaphragm (B) to be pulled away from the seat. This allows the vacuum to be transmitted to the rate valve (C). If the rate valve is open, the vacuum is transmitted through the rate indicator (D) to the regulating assemply (E). This pulls the regulating diaphragm

in regulating assembly (E) towards the chlorine inlet valve (F), opening it and allowing chlorine gas to enter the system and pass through (E), (D), (C), (B), to (A) where it is mixed with water and discharged to the point of application.

Vacuum failure allows the spring on the inlet valve (F) to move the diaphragm (E) away from the valve (F), closing valve (F) and stopping the flow of chlorine.

If valve (F) should "stick" in the open position, diaphragm (E) would be forced away from the stem of valve (F) and chlorine would pass through the centre of diaphragm (E) and out through the vent connection to the atmosphere.

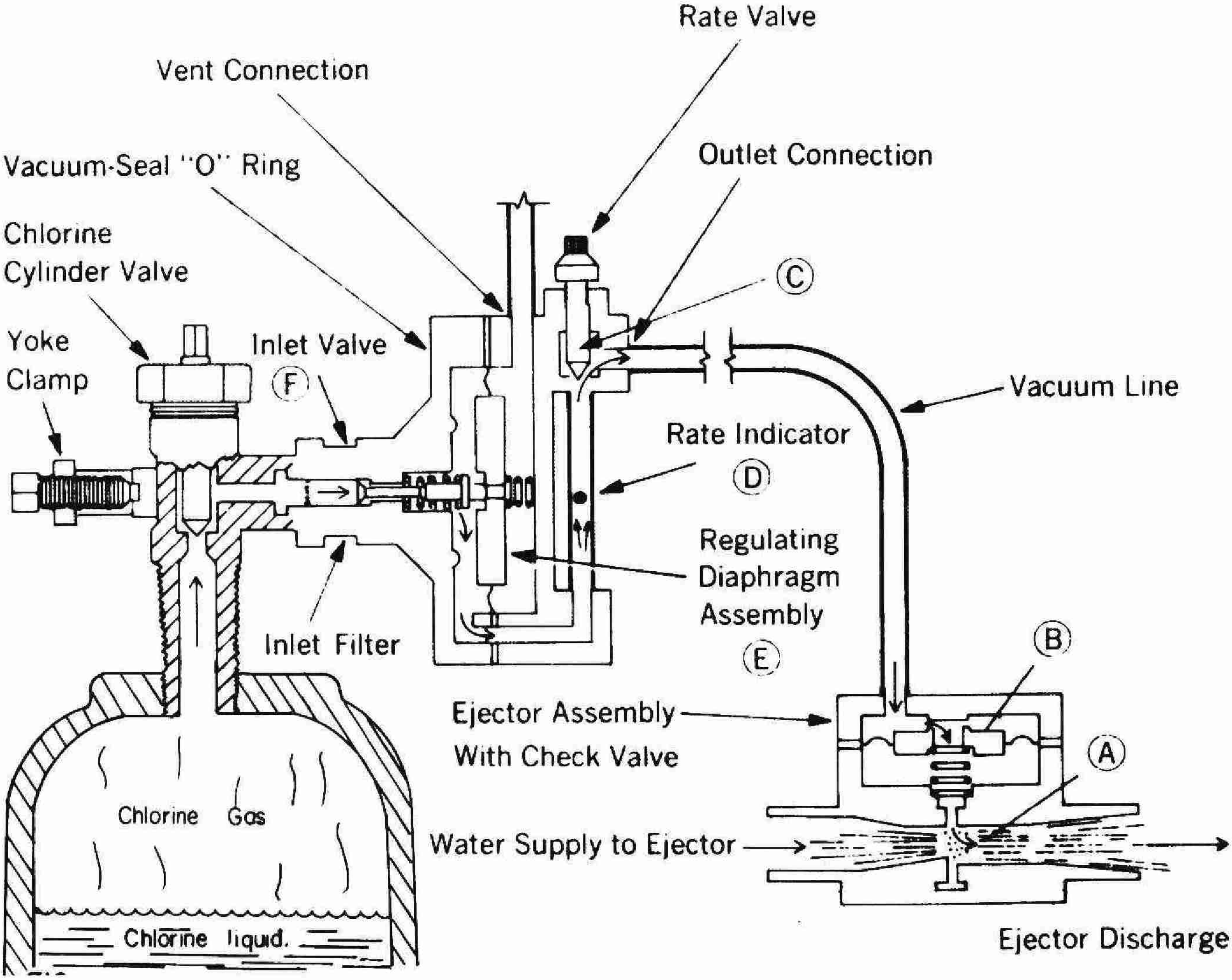


Figure 4-9 ADVANCE GAS CHLORINATOR

WALLACE & TIERNAN (W&T) BELL JAR CHLORINATOR

COMPONENTS

Figure 4-10 illustrates the flow diagram and principal components of the W&T Bell Jar Chlorinator.

Injector

See page 4-1 and Figure 4-2.

Injector failure causes loss of vacuum in the bell jar, allowing the water level to drop, lowering the ball on the CPRV, and closing off the chlorine.

Chlorine Pressure Reducing Valve (CPRV)

This is to adjust the water level in the bell jar to the zero line on the orifice meter (usually even with the top of the tray. A leaking CPRV forces water *inside* the bell jar down to a level approximately one inch below the water level *outside* the bell jar and below the bottom of the vacuum relief float. This allows the gas to pass inside the float and out to the atmosphere.

Tray Water Diversion Valve

This is normally set to split the flow between the two chambers. When water is extremely cold it is advisable to direct all the water *away* from the bell jar, to allow the water within the bell jar to warm up and to help prevent icing of the chlorine pressure reducing valve.

Tray Water Control Valve

This is used to adjust the flow of water over the weir of the collecting box. With the vacuum adjusting tube lifted clear of the water in the control chamber, the valve is adjusted so that there is a small flow of water over the weir of the collecting box.

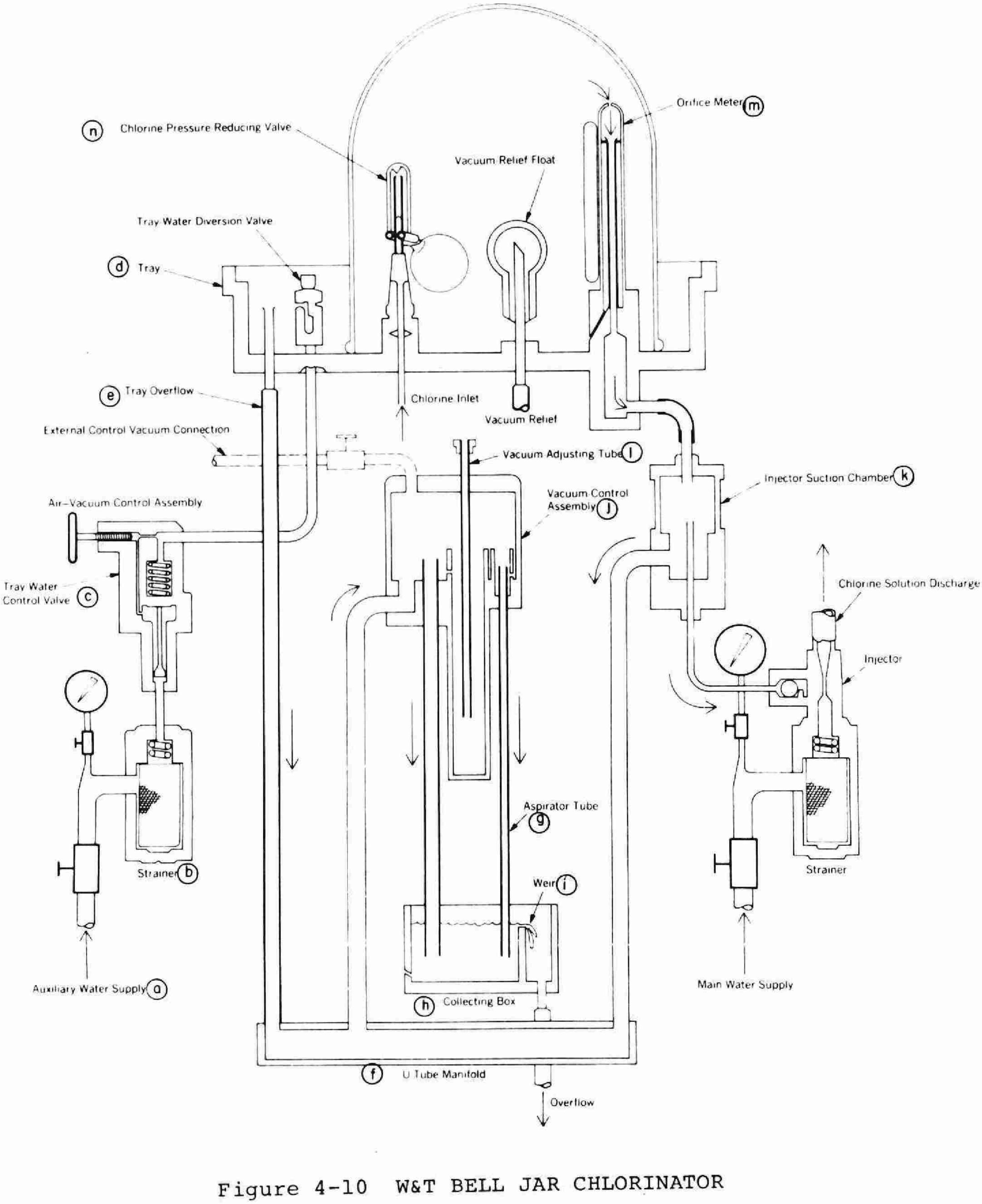


Figure 4-10 W&T BELL JAR CHLORINATOR

OPERATION

The auxiliary water supply (A) on the bell jar chlorinator supplies the water for the tray, the collecting box and the air vacuum control assembly.

After passing through the strainer (B), the water enters the unit through the tray water control valve (C). It passes to the tray (D), filling the tray to the top of the tray overflow (E).

From the tray overflow, the water fills up the U-tube manifold (F), and the air vacuum control assembly until it flows out through the aspirator tube (G) and overflows into the collecting box (H).

The end of the overflow tube and the aspirator tube are below the level of the weir (I) over which the water must flow to drain, and provide a seal for the vacuum control assembly (J).

The aspirator assembly pulls air from the control assembly by forming a vortex, giving a vacuum which controls the level of water in the vacuum control chamber (see above), and is transmitted through the U-tube manifold to the injector suction chamber (K).

The vacuum in the control chamber is controlled by the depth to which the vacuum adjusting tube (L) is lowered in the chamber. This allows more or less water to pass out of the suction chamber to the injector to satisfy the injector vacuum.

The resulting vacuum is then transmitted through the orifice meter (M) to the inside of the bell jar and is indicated on the meter.

The vacuum in the bell jar pulls the water up until it raises the float on the chlorine pressure reducing valve (N), lifting the needle valve off its seat and allowing chlorine to enter the bell jar. The greater the controlled vacuum, the higher the float is raised. More chlorine then enters the unit and is pulled through the orifice meter to the injector.

Chlorine supply failure causes the water level to increase approximately 1 1/2 inches in the bell jar, pulling air from the atmosphere into the bell jar from under the vacuum relief float.

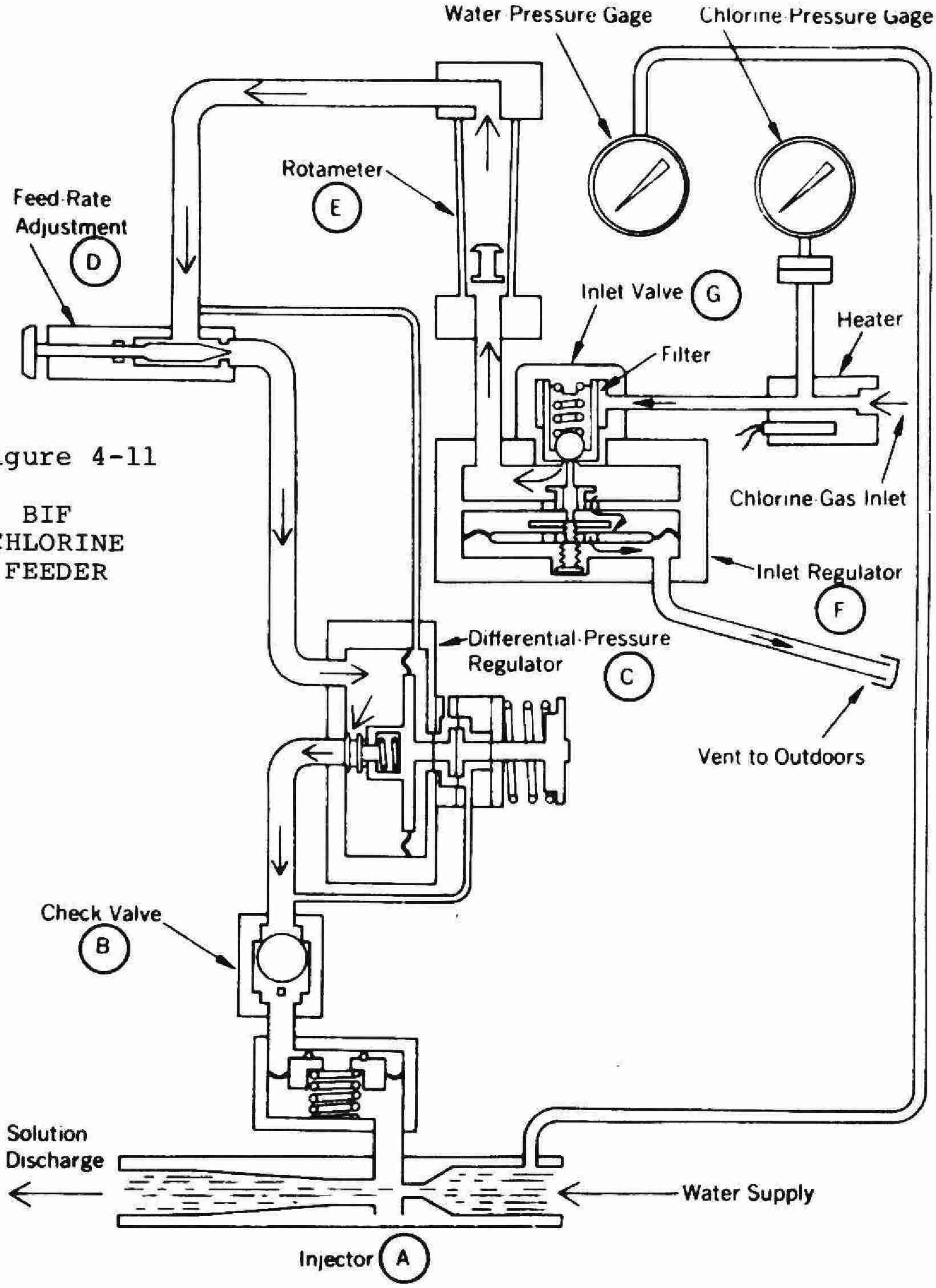


Figure 4-11

BIF CHLORINE FEEDER

BIF INDUSTRIES CHLORINE FEEDER

OPERATION (See Figure 4-11, page 4-14)

Water pressure passing through the injector at point (A) forms a vacuum which draws the diaphragm away from its seat in the check valve (B) and transmits the vacuum to the differential pressure regulator (C). The vacuum opens valve (C) and allows transmission of the vacuum to the feed rate adjustment valve (D).

Vacuum is then transmitted to the rotameter (E) and to the inlet regulator (F) to open the inlet valve (G) and allow the gas to flow back to point (A) for discharge into the system.

Failure of the injector vacuum allows the inlet valve (G) to close and stop the flow of chlorine through the system. However, should valve (G) fail to close, the resulting pressure would force the diaphragm in the inlet regulator (F) away from its seat, allowing the gas to escape through the vent to outdoors.

FISCHER & PORTER GAS DISPENSER

GENERAL DESCRIPTION

The Series 70-3400 gas dispenser (See Figure 4-12) consists of the vacuum regulator, the differential pressure regulator, and the components that comprise the safety features, all housed in a single regulator stack. Whether the safety stack regulator has a fixed range or an adjustable range, the operation of these parts is identical.

The vacuum regulator admits gas from the pressurized gas supply and reduces the pressure of the gas from supply pressure to a constant vacuum. The differential pressure regulator maintains a constant pressure drop across the orifice of the rate valve to keep the flow of the gas constant. In the fixed range regulator the pressure drop

is factory set and fixed; the adjustable range regulator provides for the manual adjustment of the pressure drop to allow the control range of the rate valve to be varied. The safety features are incorporated to prevent damage to equipment and danger to operating personnel in the event of abnormal conditions within the gas dispenser or associated equipment. The vacuum regulator, the differential pressure regulator, and the safety features are described in detail in the following sections.

In the Fischer and Porter unit, the chlorine pressure regulating valve, the pressure-vacuum relief valve and the vacuum regulating valve form ***a series of stacked diaphrams called a "safety stack regulator."***

In W&T chlorinators, the diaphragms are interchangeable.

Functional Description of the Regulators

Refer to Figure 4-12 to supplement the following functional description. The description assumes that the rate valve (the manual rate valve or the flowrator valve, whichever is present) is partially open, that the gas supply containers have been connected and the gas supply valves are open, and that the ejector water supply valve has just been opened.

As the water, under pressure, is forced through the ejector nozzle, a vacuum is created within the throat of the ejector due to the high velocity of the water as it leaves the nozzle. This vacuum builds up in the gas line between the ejector and the safety stack regulator and in the chamber designated "F" in Figure 4-12. The vacuum in chamber "F" pulls diaphragm "D" down against its stops, opening port "G". At the same time, spring "F", the atmospheric relief valve. The vacuum builds up in chamber "G" and back through the rate valve, the flowmeter, the orifice block, if present, and chamber "A". Chamber "A", diaphragm "A", port "A", and spring "A" make up the vacuum regulator.

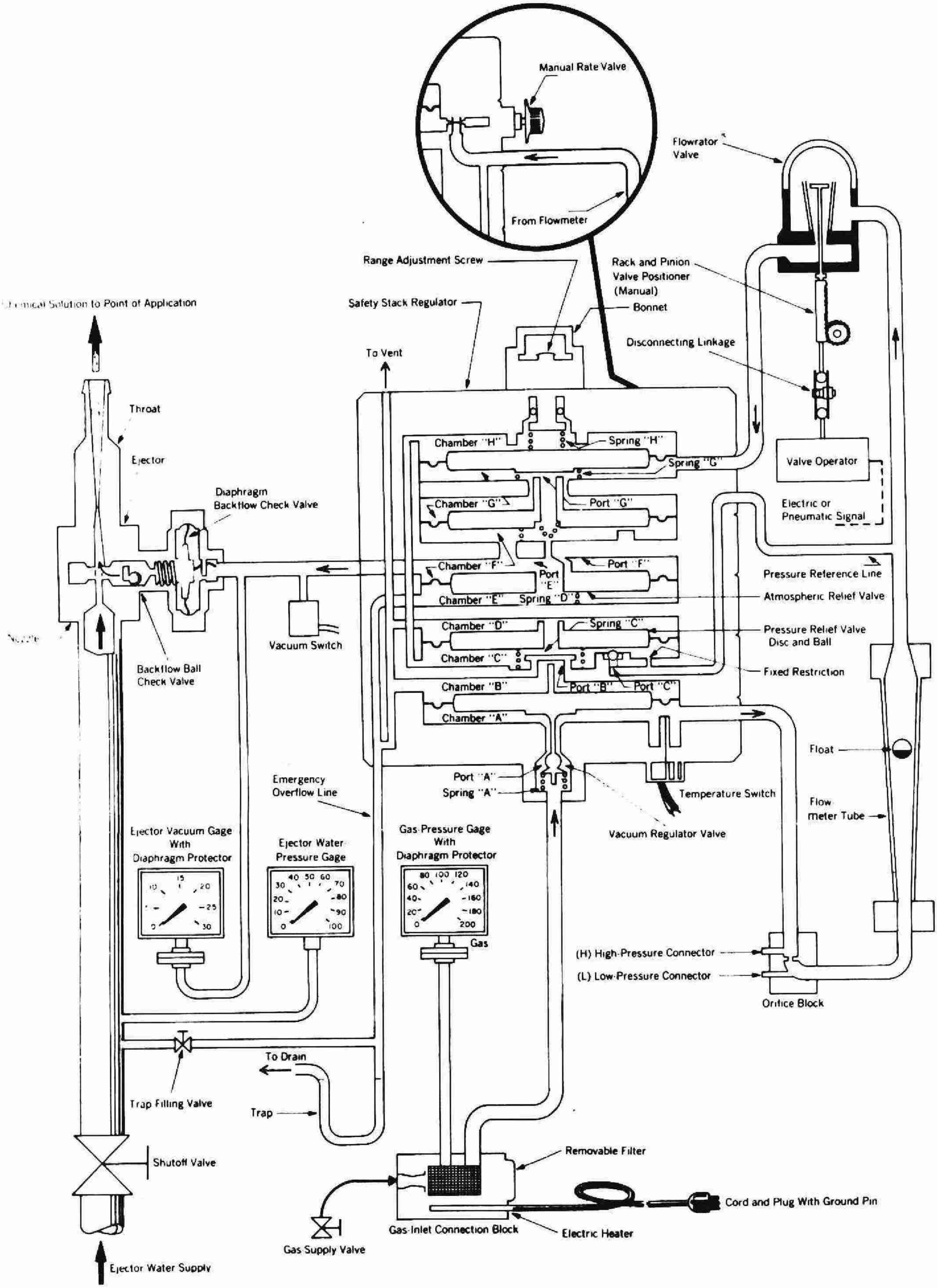


Figure 4-12 FISCHER & PORTER CHLORINATOR

The vacuum in chamber "A" pulls diaphragm "A" downward, moving the plug of the vacuum regulator valve off its seat. Diaphragm "A" is free to move since chamber "B" above the diaphragm is open to the atmosphere through the vent line. When port "A" of the vacuum regulator valve is opened, gas flows from the gas supply containers (through the gas inlet connection block) and enters chamber "A". As the gas passes through the regulator valve, it is expanded in volume and its pressure is reduced from the pressure of the supply containers to a vacuum level.

The vacuum level in chamber "A" is unaffected by the pressure level of the supply containers and is maintained constant by the throttling action of the vacuum regulator valve as controlled by the position of diaphragm "A". The downward pull of the vacuum on diaphragm "A" is constantly opposed by spring "A" which exerts a virtually constant force in the upward direction. The diaphragm is in equilibrium (and the correct throttling action is provided) when the vacuum in chamber "A" exactly balances the force of spring "A".

The gas is drawn from chamber "A" through the orifice block, if present, through the flowmeter where the flow rate is measured and indicated, and through the orifice of the rate valve which provides for manual or automatic control of gas flow rate. The gas flows into chamber "G", through port "G" to chamber "F", and finally through the back-flow check valves into the ejector. In the throat of the ejector the gas is thoroughly mixed with the ejector water to form a chemical solution which is then transported to the point of application.

Immediately upstream of the rate valve, a separate "pressure reference line" is branched off from the main gas flow. This static line transmits the vacuum existing upstream of the rate valve through the fixed restriction and chamber "C" to chamber "H" above diaphragm "E". Chamber "G"

is connected to the opposite side of the rate valve so that the vacuum downstream of the valve exists on the underside of this diaphragm (virtually constant for the small displacements of the diaphragm) that tends to open port "G". This causes more gas to flow through the port and, therefore, through the rate valve. This increases the pressure drop across the orifice of the rate valve; the increased differential also exists across diaphragm "E" and pulls the diaphragm downward, tending to close port "G" and throttle the flow of gas.

When precisely enough gas flows through port "G" so that the spring tension is exactly opposed by the differential acting on diaphragm "E", the diaphragm is restored to equilibrium. Thus, chamber "H", diaphragm "E", chamber "G", spring "G", and port "G" make up the differential pressure regulator that maintains a constant pressure drop across the orifice of the rate valve. This keeps the flow of gas through the rate valve (and, therefore, through the gas dispenser) constant for each valve setting and compensates for any variations that may occur in the vacuum level at the ejector.

As shown in Figure 4-12, the adjustable range safety stack regulator includes an additional spring "H" and a range adjustment screw. The tension of spring "H", which can be manually adjusted with the range adjustment screw, partially cancels the tension of spring "G". In effect, this allows the tension of the differential pressure regulator spring "G" to be adjusted so that the pressure differential across the rate valve can be varied. Therefore, the flow rate through the valve can be adjusted (without changing the valve setting) until the gas is flowing at 100% of dispenser capacity when the rate valve is fully open.

Figures 4-13 to 4-16 illustrate gas flows and safety features of the Fischer and Porter Chlorinator.

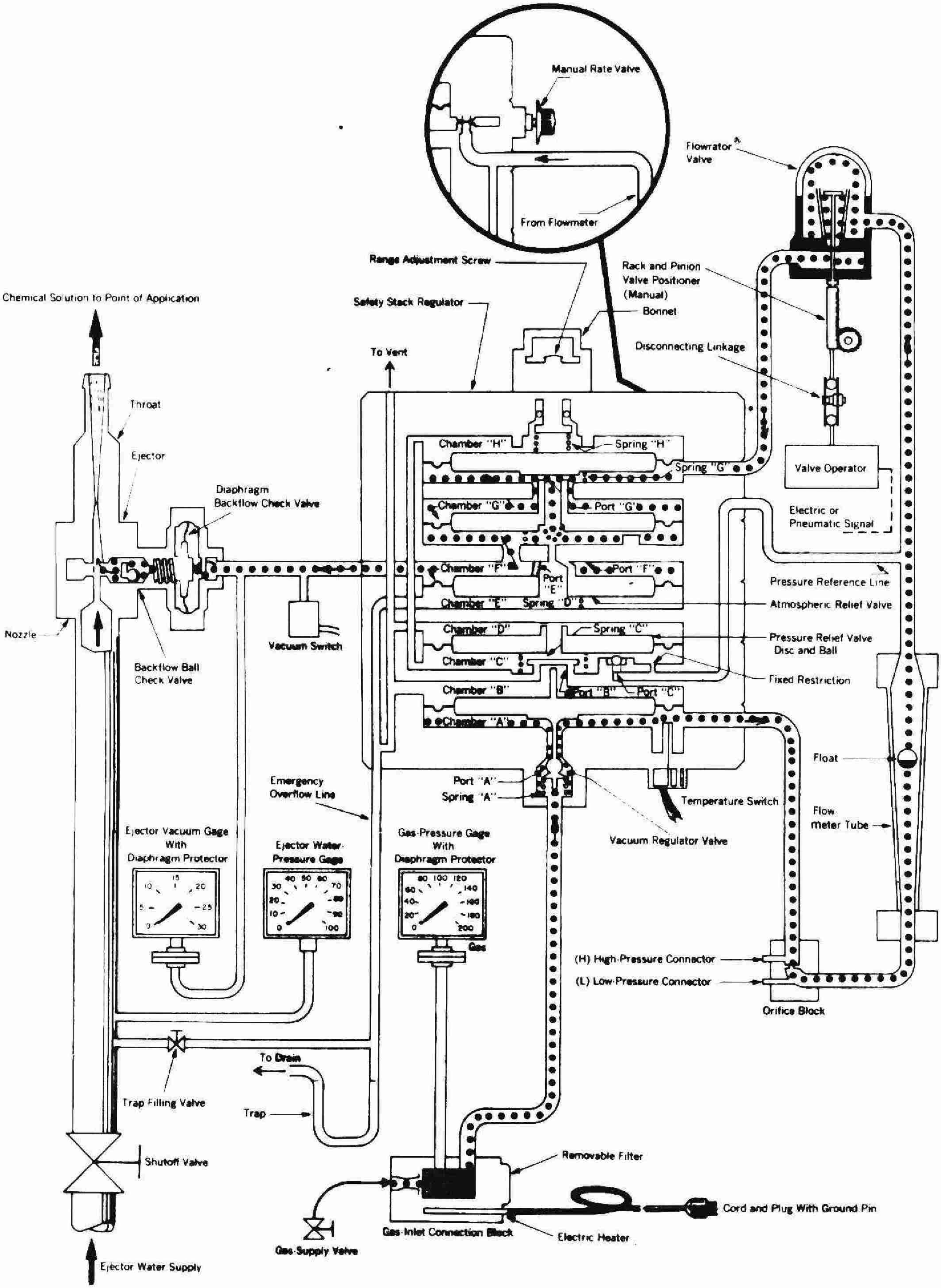


Figure 4-13 NORMAL OPERATION

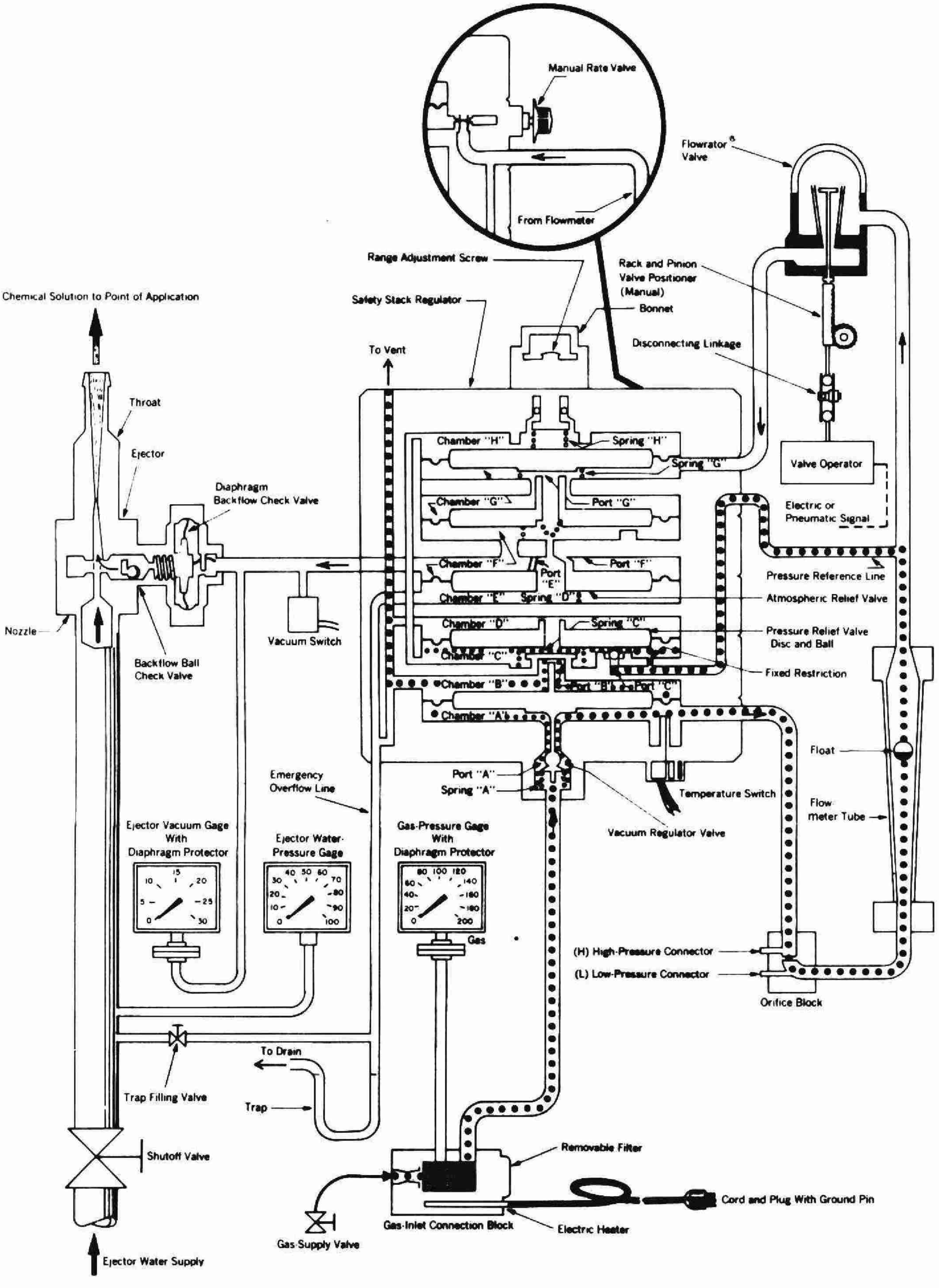


Figure 4-14 PRESSURE RELIEF

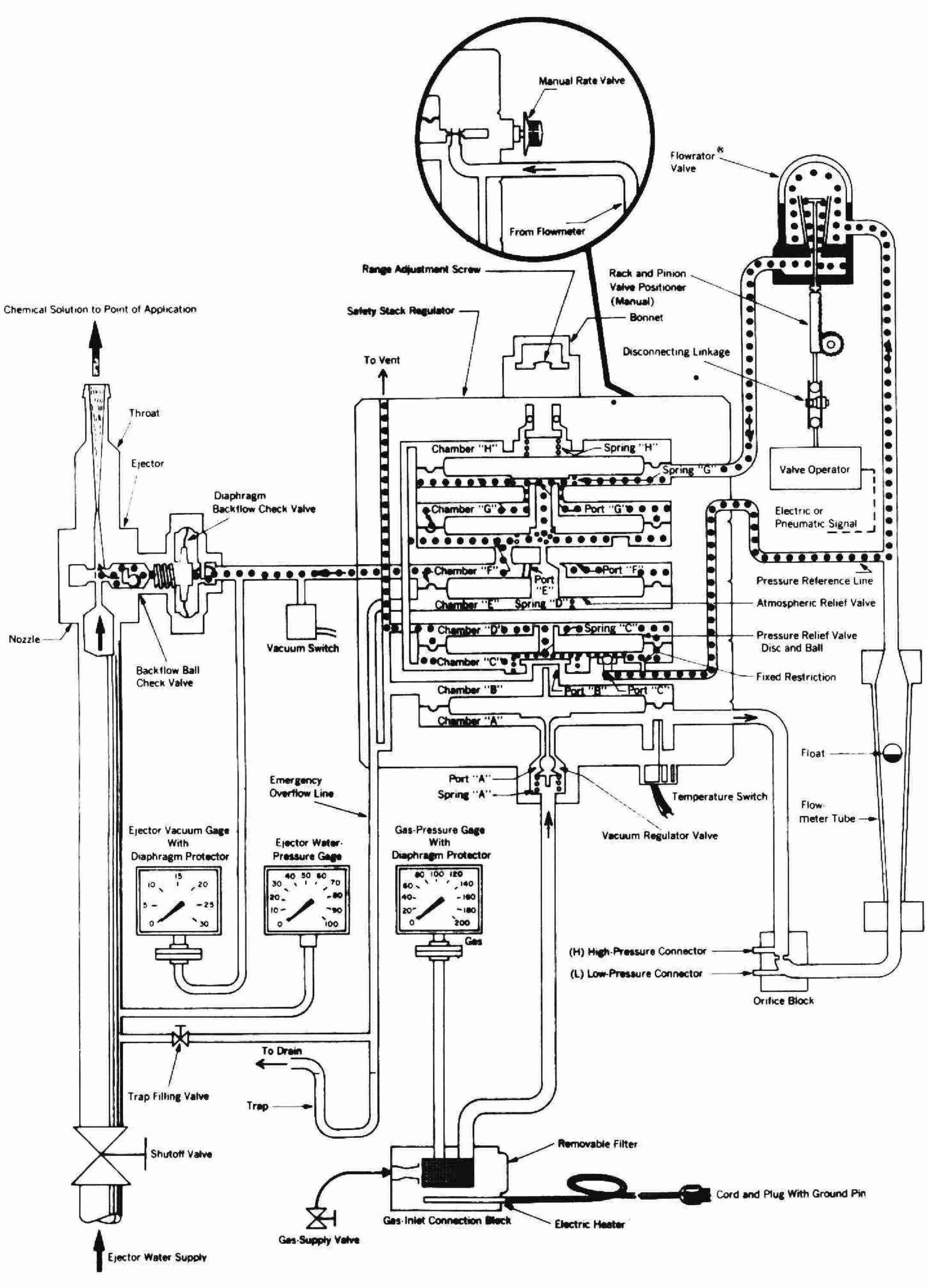


Figure 4-15 VACUUM RELIEF

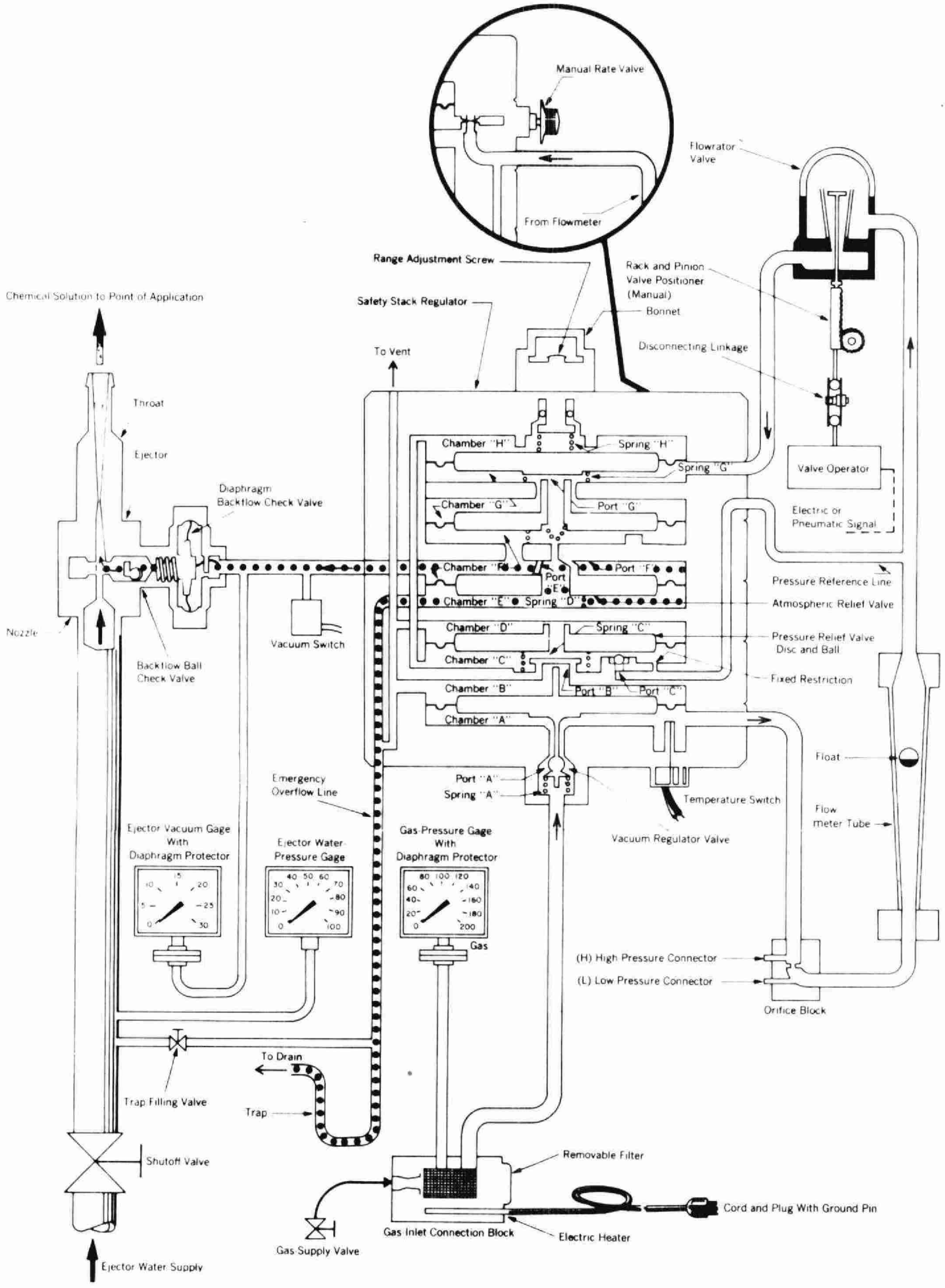


Figure 4-16 FLOODING PROTECTION

SUBJECT: 2

CHLORINATION EQUIPMENT

TOPIC: 5

CONTROL SYSTEMS

OBJECTIVES:

The trainee will be able to

1. Recall the types of chlorine control systems and the use of each.

2. Describe the chlorine control systems.

3. Recall the purpose of

   a) The Residual Analyzer Recorder

   b) The Residual Recorder Controller

TYPES OF CONTROL SYSTEMS

The chlorine control systems available include:

1. Manual system
2. Flow proportional or open loop control
3. Direct residual or closed loop control
4. Compound loop control

Manual System

1. The rate of feed is varied by hand.
2. It is only suitable at points: (i) where flow of sewage or water to be treated is constant, (ii) where the flow rate is changed manually (eg. when starting a second pump), at which time chlorination feed can be adjusted to the new flow.

Flow Proportional or Open Loop Control (See Figures 5-1, 5-2)

In the flow proportional or open loop control system:

1. An adjustment is made in accordance with a command signal from the flow meter or pump starter. Response is *assumed* to be correct.
2. Any signal from a primary measuring device (orifice, venturi, etc.) can be fed directly or converted to proper form by a *transducer* to allow electric or pneumatic positioning of chlorinator control units.

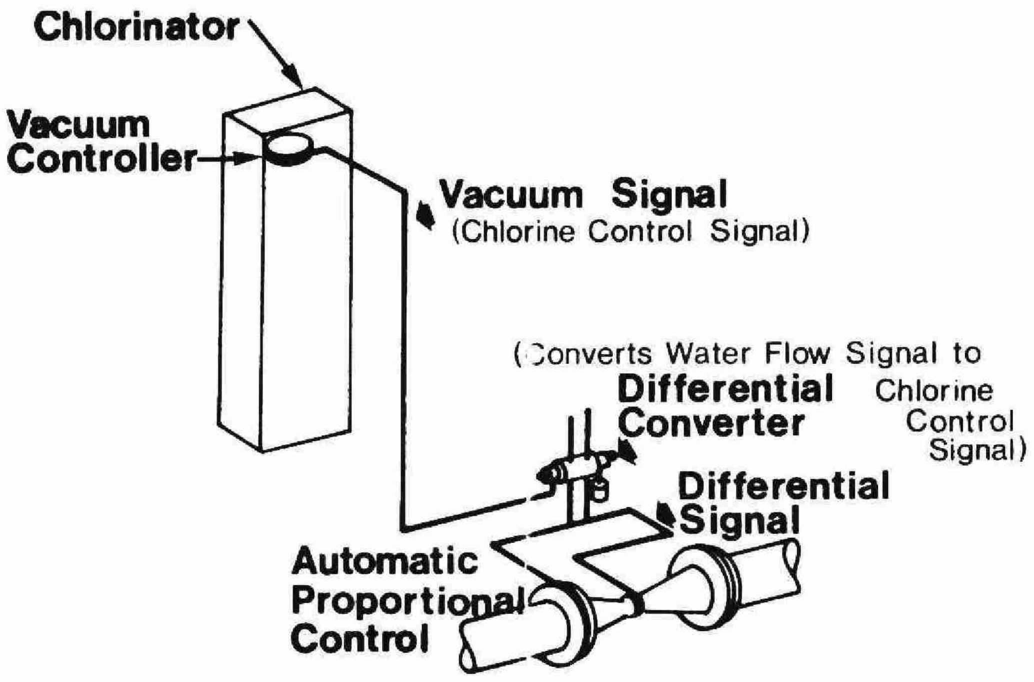


Figure 5-1

OPEN LOOP CONTROL

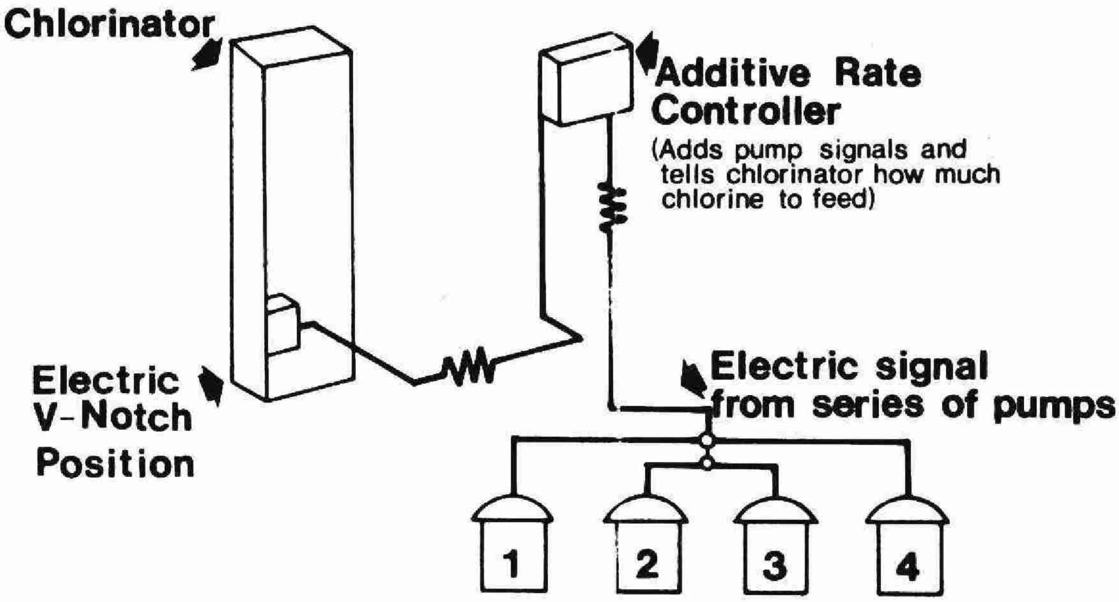


Figure 5-2 OPEN LOOP CONTROL

Note: *When flow varies and chlorine requirements remain constant, flow proportional or open loop chlorination control is used.*

Direct Residual or Closed Loop Control (See Figure 5-3)

The direct residual or closed loop control system operates as follows:

1. A sample of chlorinated water is continuously withdrawn downstream from point of chlorination and analysed. (See Page 5-5 for information on the Chlorine Residual Analyzer).
2. The recorder compares the *measured* residual with the *desired* or set residual to see if the chlorine feed rate should be increased or decreased. It then sends a signal to the chlorinator control device to make the change.

3. Types of signals used include:

   (i) an electric signal
   (ii) a pneumatic signal
   (iii) a vacuum signal

Note: *When flow remains constant, but chlorine requirements do not, direct residual control is used.*

Why is it called a closed loop?

Measurement of end result is made and information is fed back to the chlorinator control for comparison with control set point.

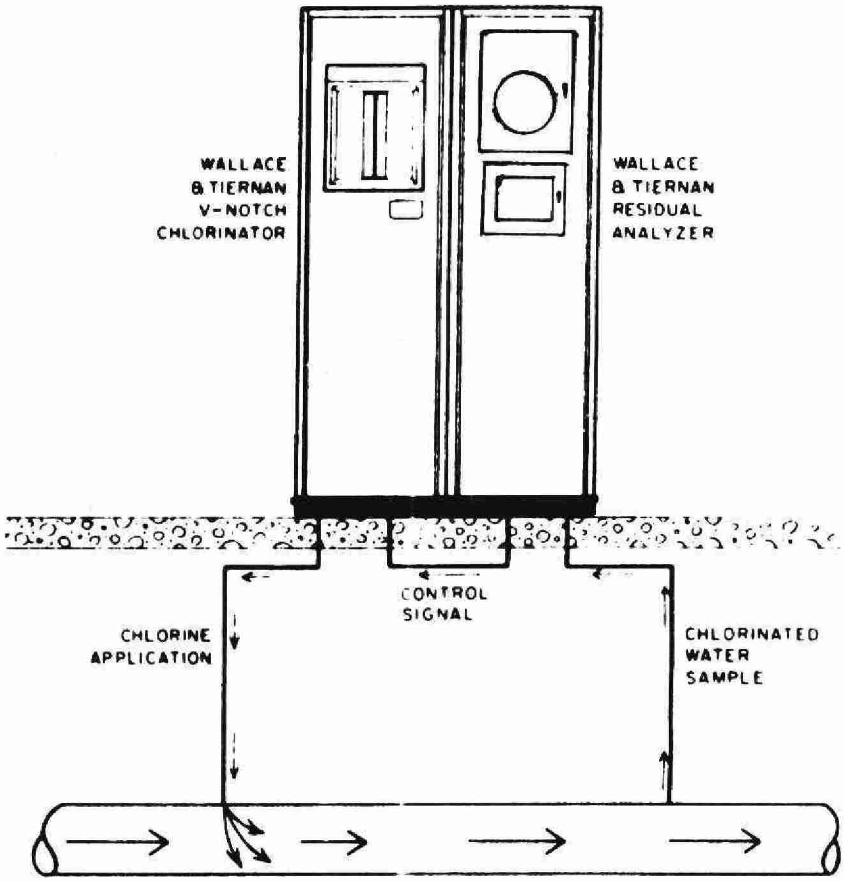


Figure 5-3 CLOSED LOOP CONTROL

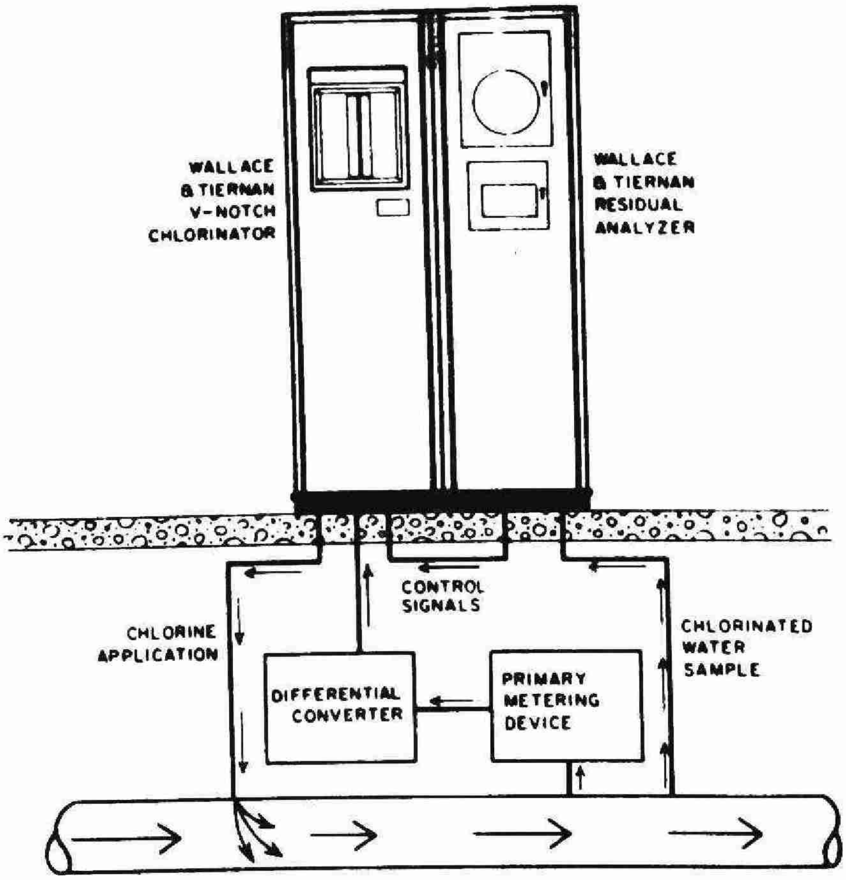


Figure 5-4 COMPOUND LOOP CONTROL

Compound Loop Control (See Figure 5-4)

The compound loop control system is a combination of open loop and closed loop systems. When flow increases, the chlorinator adds the correct amount of chlorine to keep the present dosage level. A sample is withdrawn downstream and analysed to determine if chlorine demand has changed. If so, information is relayed back to the chlorinator and correction in dosage is made according to the new chlorine demand.

Note: When both flow and chlorine requirements may vary, compound loop chlorination control is used to maintain desired residual of chlorine in water.

Compressors

Compressors used for air control signals must be maintained to produce a clean, moisture-controlled air supply to the instrument. For trouble-free operation of the recorders, the air should pass through a filtering cell to remove suspended oil and dust particles, and a drying unit to remove moisture.

RESIDUAL ANALYZER RECORDER

Purpose

The purpose of the residual recorder is to indicate and record the residual of chlorine in a plant discharge/or at any point within the plant. (See Figures 5-5 and 5-6)

Principle of Operation

A controlled sample of water is fed into a cell having two electrodes of different metals (Bronze and Platinum).

A buffer solution is added to maintain the pH within a pre-determined range.

The presence of chlorine in the water sample acts as an electrolyte between the two different metals and causes a small D.C. electrical current which is proportional to the amount of chlorine in the sample.

This is basically a *titrator* working on a continuous basis.

The small electrical current generated by the cell assembly (analyzer) is fed into an amplifier system and changed to a control voltage to activate a servo motor. The servo motor drives a gear train to position the pen on the chart and the feed-back potentiometer in the balancing circuit until the control voltage and balancing voltage are equal. At this point, the motor stops.

An increase or decrease in the chlorine residual of the water entering the cell will cause a corresponding change in the position of the pen on the chart.

The operation of this unit must be checked daily or weekly (as experience will dictate). It can only be checked accurately with the use of an amperometric titrator (See Topic 11).

The residual recorder can be used to record either free or total chlorine residual.

For free chlorine residual recording, a pH 7 buffer solution is used, and for total chlorine residual, a pH4 buffer plus iodine tablets are used. In some cases where reading total chlorine residual, if the pH of the water is within certain limits, a buffer solution is not required.

Chlorine Residual Alarms

Chlorine residual alarms can be activated by the use of electrical contacts adjustable to any point within the range of movement of the pen. These contacts activate a relay to pull in an alarm system, and will not handle the amperage required to operate the alarms.

RESIDUAL RECORDER CONTROLLER

Purpose

The residual recorder controller continuously indicates and records the residual of water, and raises or lowers the chlorinator setting accordingly.

Principle of Operation

This equipment is exactly the same as described under "Residual Recorder" with the addition of electrical contacts and "set point" control, plus relays, to control the increase or decrease of the chlorinator feed.

The residual recorder controller allows a "loop system" for automatic control in a plant (See Figure 5-4).

Maintenance Problems

The time involved in the transfer of water and sample through the control loop system is critical. The manufacturer's specifications must be followed very closely to set up and regulate the equipment for the best operating conditions in the treatment plant.

Maintenance

1. Clean the cell assembly as required by the suggested maintenance program and/or as dictated by operating conditions. Use the method, materials, etc., described in the manufacturer's specifications.
2. Regularly inspect the leads from the cell (analyzer) to the recorder unit for possible corrosion. This is particularly important for older models of equipment.
3. Clean the electrical contacts whenever they look dirty or seem unreliable.
4. Use a voltmeter with a low range D.C. millivolt scale to indicate whether or not:
   a) the cell and electrode assembly is producing an electrical signal,
   b) the amplifier is converting this signal to the motor requirements.

Also use a voltmeter to verify if the contacts are energizing the required alarm or control circuits. The manufacturer's electrical drawings will indicate where to check this, and what voltage readings to expect.

5. When taking gears or mechanical linkages apart, mark them with check lines to simplify reassembling into their original positions.

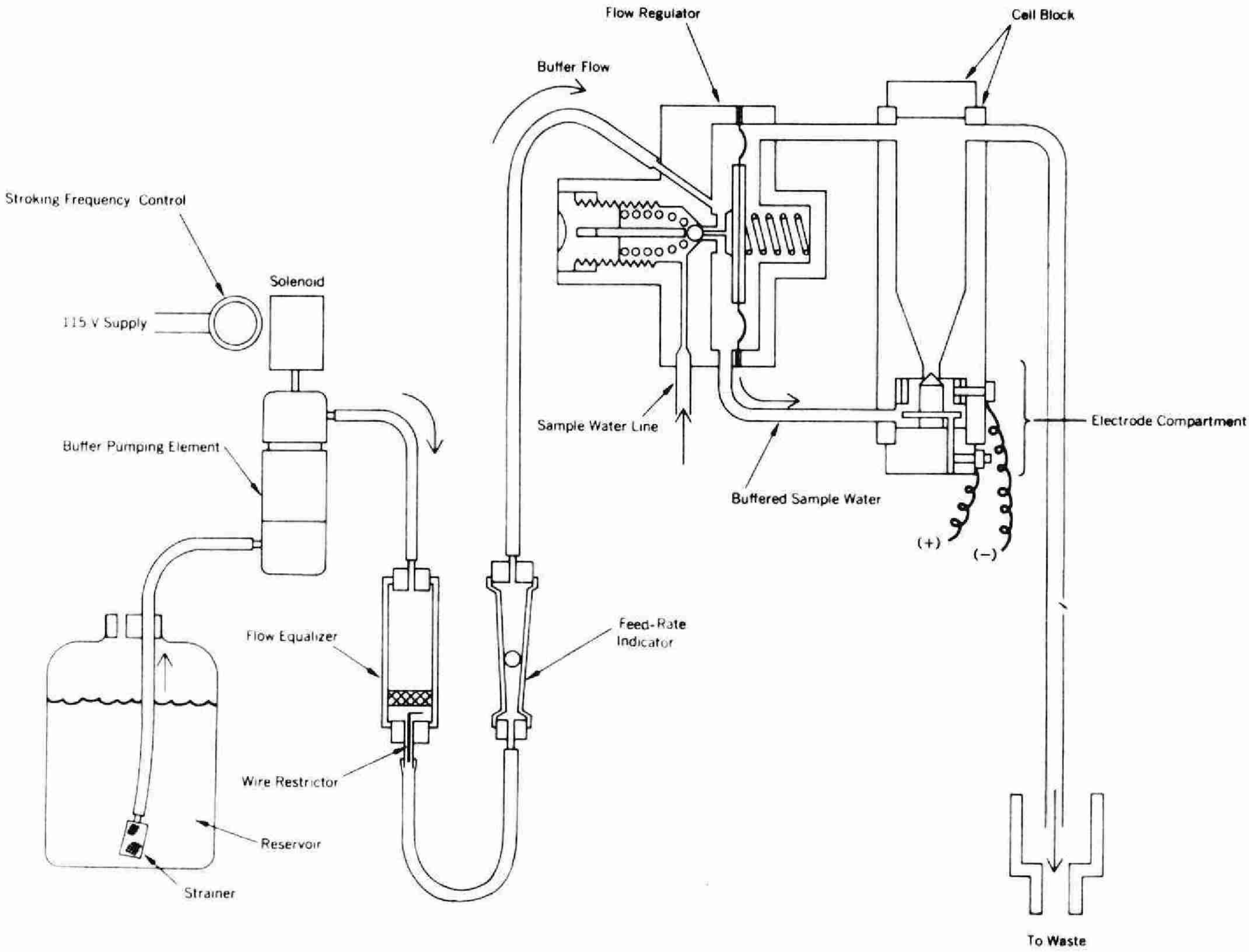


Figure 5-5 RESIDUAL CHLORINE SAMPLING CELL FOR WATER

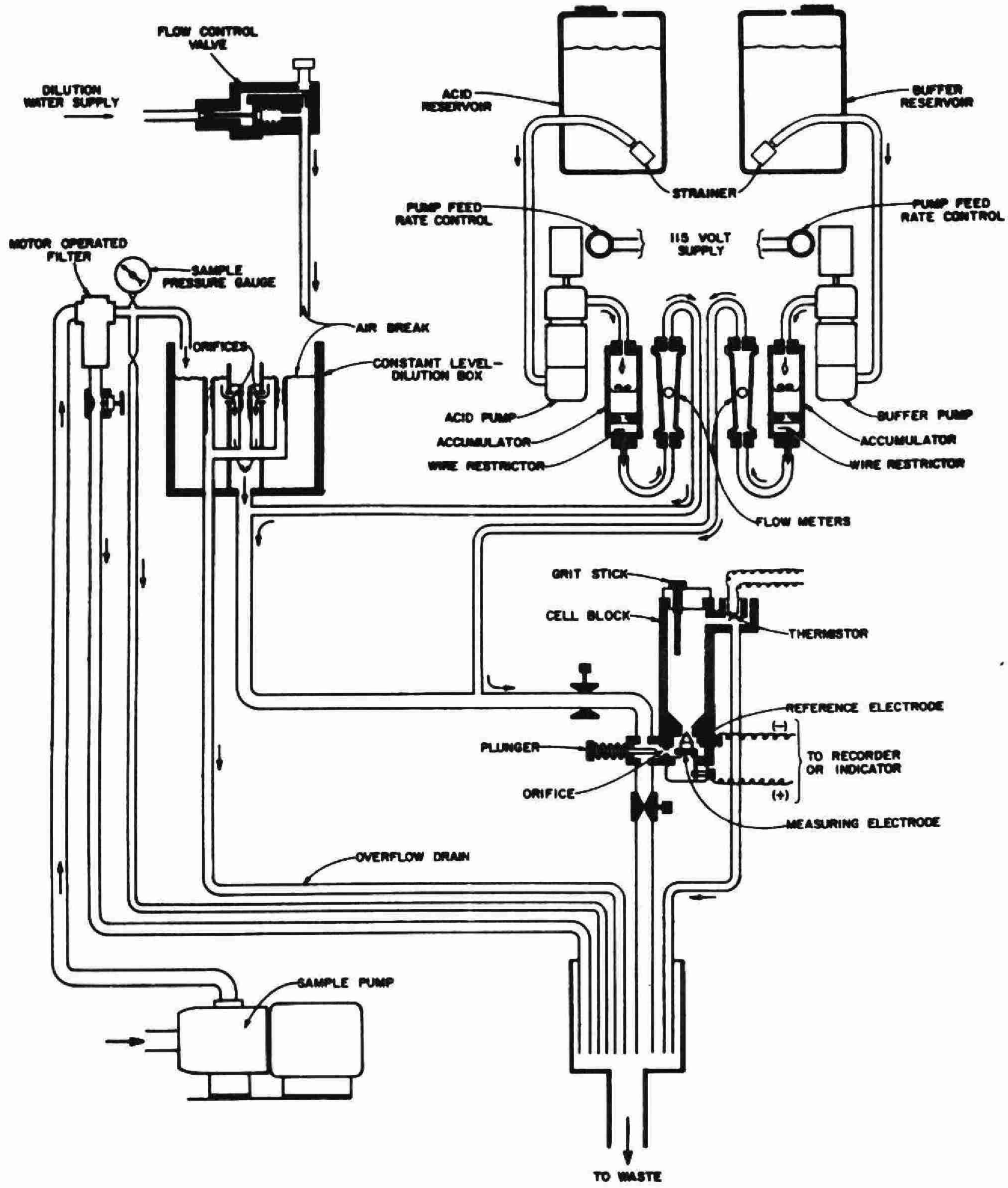


Figure 5-6 RESIDUAL CHLORINE ANALYZER
FOR WASTEWATER OR INDUSTRIAL WASTE

Recording Chart and Pen (See Figure 5-7)

A recording chart is used to record the daily consumption of chlorine. When positioned, the chart must be free to move, not binding in any way. When changing charts, always check the time to make sure the chlorine consumption is recorded at the proper hour on the chart.

Chart pens are supplied with ink by (a) capillary tube or (b) trough type pen.

a) The *capillary tube* has a double effect: it cleans the tube while loading the pen.

b) The *trough type* pen should be cleaned of all congealed ink at regular intervals and should be replaced when the tips of the pen become worn.

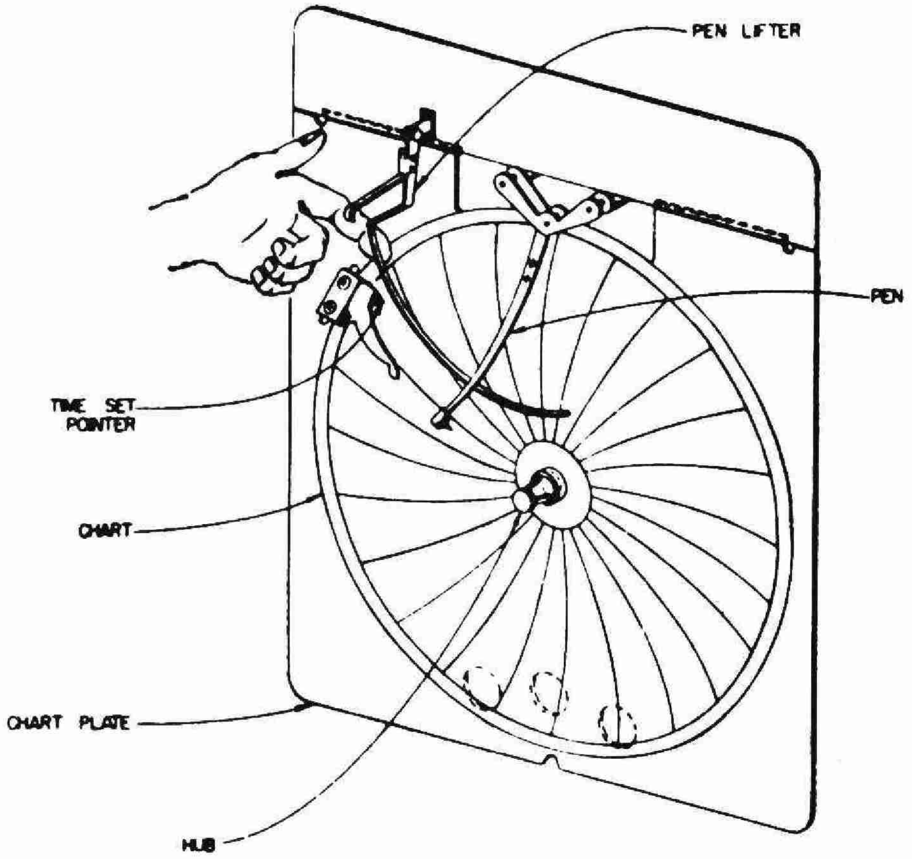


Figure 5-7 RECORDING CHART

SUBJECT: 3

CHLORINATION SYSTEM OPERATIONS

TOPIC: 6

SAFETY PRACTICES

OBJECTIVES:

The trainee will be able to

1. Recall the hazards associated with chlorine.
2. Recall the general safety procedure if a leak is detected.
3. Describe the remedies for
   a) liquid leaks from cylinders
   b) leak at the valve packing
   c) leak at a fusible plug.
4. Recall the purpose of rupture discs.
5. Recall the safety procedures in emergency situations.
6. Demonstrate the use of the 15 minute air pack.
7. Demonstrate and/or describe the first aid procedures used in handling casualties resulting from exposure to chlorine.

SAFETY PRACTICES

GENERAL

Chlorine is a potential killer when the chlorine handling equipment, although well designed, becomes defective or when people become careless. Even when all regulations are observed, safety practices followed and well-trained crews are employed, there is still a chance that an accident will occur.

To avoid accidents when working with chlorine, follow the safety procedures carefully. In the event of a mistake or accident, however, suitable air packs should be available so that emergency measures can be taken. The chlorinating room itself should be adequately ventilated with a separate ventilating system capable of removing the air from the room once every four minutes. This ventilation should be located at a low level in the room because the chlorine gas is heavier than air. Any room with chlorine containers should have two exits and the doors should open outwards for easy escape. Air packs should be located just outside the chlorinating room as should the switches for the ventilating system and lights.

Chlorine can be detected by equipment or even by smell in very small dosages. The least amount of chlorine in the atmosphere detectable by smell is about 3.5 mg/l, and when this occurs, the operator should be alerted to potential hazards, such as leaks or faulty equipment. At high concentrations, chlorine will affect the body. Appendix A discusses chlorine detection using installed alarm systems.

Because higher concentrations of chlorine cause irritation of eyes, coughing and laboured breathing, it is unlikely that any person would remain unprotected in a contaminated area *unless he were unconscious or trapped.*

The symptoms of advanced stages of exposure are retching and vomiting followed by difficult breathing. In extreme cases, the difficulty with breathing may increase to a point where death can occur from suffocation.

The maximum amount that can be inhaled for one hour without serious effects is about four (4) mg/l. At fifteen (15) mg/l, chlorine will cause irritation of the throat; at thirty (30) mg/l, it will cause serious coughing spells; and at forty (40) to sixty (60) mg/l, it is extremely dangerous for one-half hour exposure. A few breaths of air containing 1,000 mg/l may kill a man.

TABLE No. 6-1

WARNING - THE EFFECTS OF CHLORINE GAS

	Chlorine (mg/l)	
You can breathe no more than	*4.0*	*safely for 1 hour*
It will take at least	*1.0*	*for several hours before you show symptoms of poisoning*
	3.5	*before you can smell it*
	15.1	*to cause throat irritation*
	30.2	*to make you cough*
	40-60	*to be dangerous in 30-60 minutes*
	1000	*to kill you in a few breaths*

Standard Safety Practices

1. Practise personal hygiene. See Appendix B.
2. Always wear safety goggles (or face shield) and gloves.
3. Always turn on the chlorine exhaust fan when entering the chlorine room.
4. All persons using the gas protective equipment must be trained in its use and maintenance.
5. Do not start up or operate a chlorinator or turn on a chlorine cylinder unless adequate protective equipment (air pack/respirator) is on hand in the chlorine room area.
6. A self-contained air pack must be worn when it is necessary to locate and stop small leaks in the piping or when making any repairs or adjustments to *leaking* equipment or if the concentration of the chlorine gas in the air is unknown.
7. A self-contained air breathing unit must not be used unless the air cylinder is fully charged. *Air cylinders must be completely recharged after each use.*
8. Never apply water to a chlorine leak because of the added corrosive action created by the water and chlorine mixture.
9. All removable parts of the chlorinator such as cylinder clamps, metal hose connections, couplings, headers, valves, etc., should be removed at the end of the chlorinating season, cleaned and inspected, and worn and damaged pieces replaced.

TYPES OF LEAKS ENCOUNTERED - AND THEIR REMEDIES

Liquid Leak

One basic and very important rule when dealing with chlorine leaks is always to keep the leak in the vapour phase. This is usually quite simple in the case of 150-lb. cylinders, since they are stored and usually used in an upright position. With one-ton cylinders, however, liquid chlorine could easily leak through a valve or a fusible plug. Liquid chlorine will vaporize to approximately 450 times its volume as a gas.

The leak will be greatly reduced by rolling the tonner (if possible) into a position where gas is escaping instead of the liquid chlorine. As the gas escapes, the liquid will refrigerate itself, lowering the vapour pressure.

Leak at Valve Packing

This can be caused by dried-out packings. In this case, chlorine will be coming out around the valve system and cannot be stopped by tightening down the packing gland nut. This should only occur when valve is opened.

If leak is very slight, hook up cylinder and start drawing chlorine at maximum rate. This should quickly reduce the pressure and probably stop the leak. If leak is of major proportions and does not respond to this treatment:

- shut off valve
- set cylinder outdoors *in the shade*
- call supplier who will pick up cylinder or replace the packing.

Leak at Fusible Plug

This is usually due to corrosion from moisture, either internally or from the outside.

1. Cylinders

One manufacturer has a special clamp with a rubber pad and steel backing which easily controls this type of leak. The adapter clamp can also be used to stop this type of leak. Take a flat file and file the area around the fusible plug flat. Apply a small patch of synthetic rubber gasket material with a follow-up piece of metal and clamp this firmly in place.

NOTE:

This emergency device now leaves the cylinder without protection from high temperatures. Use up the chlorine in the cylinder as rapidly as possible.

2. One-Ton Container (Tonner)

a) Leak can be at the fusible metal plug or at the threads around the plug. If leak is through the fusible plug, there is a special clamp of rubber and steel which readily controls the leak. If the leak is around threading of the fusible plug, the Chlorine Institute emergency kit may have to be used. *Remember:* when a fusible plug clamp is applied to a 150-lb. cylinder, the safety device no longer exists and it must be emptied as quickly as possible. Since there are six fusible plugs on a tonner, sealing off one of them still leaves five operating safety devices which should be enough, under most circumstances.

b) Rupture Discs. A rupture disc is used on liquid lines on the larger installations, such as ton containers or tank cars. The disc is designed to protect the equipment and will rupture (break) when

the pressure in the chlorine manifold system reaches a pre-determined value greater than normal operating pressure, but less than maximum allowable pressure. A typical installation is as follows:

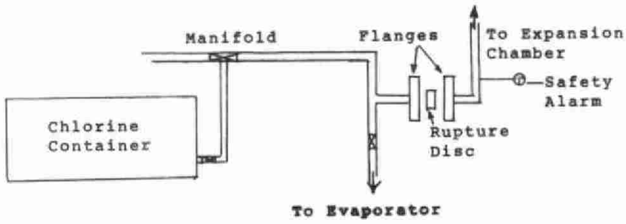


Figure 6-1 RUPTURE DISC

The rupture disc is placed between two flanges in the line to an expansion chamber. This line comes off the manifold between the chlorine container and the evaporator. This safety device should be installed in any section of liquid piping which can be isolated, either purposely or accidently, by closing valves.

Valves are carefully checked before leaving the manufacturer's plant, but occasionally a valve may be stiff to turn or difficult to shut off tight. This may be caused by a small piece of scale or other foreign matter at the valve seat. Sometimes the valve can be freed by opening and shutting a few times (with the outlet cap in place and by tapping the body of the valve). Actually, once the cylinder is hooked up, inability to completely shut off the valve is not important and contents can be withdrawn until empty. When cylinder has been discharged (and only gas remains in it), the outlet cap with a good fibre gasket will effectively stop chlorine from escaping.

Valve Defect - "Turning Spindle"

The most troublesome type of valve defect (although fortunately not the most common) is known as a "turning spindle". Actually this is a situation where the brass threading on the valve body has been stripped by the harder Monel metal of the valve stem.

If this condition develops *after* the cylinder is hooked up to the chlorinator, the simplest and safest way to deal with it is to continue withdrawing chlorine until the cylinder is empty. However, if the cylinder has not yet been hooked up, then an emergency device is required to deal with the situation.

One manufacturer, CIL, has developed a small unit which fits on top of the valve, and by exerting pressure against the packing gland nut, pushes the valve stem into position. While this device will work in most instances, there are some situations where the use of the larger Chlorine Institute equipment with the capping device is required.

Removing Valve Outlet Cap (on Cylinder or Tonner)

ONE VERY IMPORTANT WORD OF CAUTION - when taking off the valve outlet cap (on cylinders or tonners) *DO IT VERY SLOWLY.* Actually, if there is a leak of chlorine past the valve, this will be very noticeable after the cap has been slackened only one turn. Use the ammonia bottle at this stage, and wear an air pack. Very small concentrations of chlorine can be detected by smell, and for this reason it is sometimes desirable to leave the face-mask off - just in case there are leaks. However, the air pack should be *immediately available* if required.

AS A LAST RESORT - CONTACT MANUFACTURER!

If these remedies do not solve the leaking problem, CONTACT THE MANUFACTURER. In some cases, a telephone call may provide the operator with the necessary information to correct the leak.

If this is not enough, the manufacturer's technical personnel should come, bringing the necessary emergency equipment to stop the leak.

SAFETY PROCEDURES - LEAK DETECTION

If you smell a leak:

1. Put on air pack. See Appendix C, for procedures for use of air packs and canister respirator.

   NOTE:

   Air packs should be located within 15 feet of the door leading to the chlorine room.

2. Turn on exhaust fan of chlorine room. Check fan discharge point and be sure personnel or equipment are not in the way. If there is a casualty, remove him immediately. Apply first aid. See Appendix D.

3. Shut off cylinders. If leak is large, or if the equipment has been leaking for some time, the room is full of gas.

   NOTE:

   No tests can be made on equipment for leaks until room is cleared.

   DO NOT ATTEMPT A REPAIR ALONE.

4. Notify supervisor immediately. If the leak cannot be repaired, institute the emergency procedures described starting on page 6-10.

5. To test for leak AFTER room is cleared:

   a) Use bottle of concentrated ammonia near joints, piping or valves suspected. *White fumes of ammonium chloride indicate the location of a chlorine leak.*

   b) Crack open cylinder FARTHEST from chlorinator until gauge shows approximately 40 lbs.

   c) Shut off cylinder and test system to find leak(s). *It may be necessary to repeat above action several times to find all leakage.*

6. When location of leak is found:

   a) Mark it off clearly.

   b) Shut off gas supply and *keep supply shut off until leak is repaired.*

   c) Use proper tools for repair; do NOT handle equipment with unnecessary roughness.

   A green slime, due to the gas and/or the chemical reaction, may form where a leak was repaired. A *dry* cloth should be used to wipe away the slime. The moisture from a wet cloth would combine with the slime, possibly creating another leak.

   NOTE:

   If this green slime has dried to a dust, do not blow it with your mouth or brush or wipe it unless the area is completely ventilated.

   AVOID BREATHING THIS DUST. Even minute particles are highly dangerous.

7. If leak is not repaired before shift change:

   a) Advise next operator of what has happened.

   b) Advise him of procedures to follow.

   NOTE:

   If operator of first shift is alone, he should enlist the aid of the operator relieving him to check out equipment, repair leak and leave equipment in operational order before leaving.

SAFETY PROCEDURES IN EMERGENCY SITUATIONS

Suppose there is a leak from a cylinder which cannot be stopped or repaired, such as a leaking fusible plug, damaged cylinder valve, or a hole in the cylinder body. The following steps should be taken:

1. Protect yourself AT ALL TIMES during the emergency, and be sure you will not be overcome by the leaking gas. Use an air pack when in the area of the leaking cylinder.

2. Keep the leak in the vapour phase. Cylinders and tonners should be placed so that *gas and NOT liquid* is coming off.

3. Contact your supervisor immediately and advise him of the problem.

4. If you cannot contact your supervisor, telephone the Police Department to tell them of the problem. Advise the police of the wind direction (if any) so they in turn can alert the residents who may be in the path of the gas and have the area evacuated. The police or operator should also contact the Fire Department who in turn should have someone with an auxiliary air pack go to the plant or leaking area. This person (or persons) could then stand by while you try to stop the leak.

5. Contact the supplier, or manufacturer, of chlorine. The suppliers operate an emergency telephone call service designed to provide assistance at any hour of the day or night.

6. Inter-connecting doors within the plant should be CLOSED, AND THE CHLORINE ROOM SEALED OFF. The chlorine room exhaust fan should NOT be turned on as this would release an excessively strong concentration of chlorine outside the plant. The chlorine gas will slowly escape by itself if left alone, which is a better alternative, particularly if the leak occurs at night. If the leak occurs

in the daytime, the sun will dissipate the gas quite effectively, even on a cloudy day. If the weather is hot and humid, or rainy, or foggy, the chlorine will not dissipate as quickly, and there is very little which can be done except to evacuate all the people in the area. If there is a wind, the residents who may be in the path of the gas must be evacuated.

7. If the chlorine leak occurs in a water treatment plant, it may be necessary to shut down operation and use only the water in the reservoir(s). If this reserve is inadequate and the plant cannot be shut down, then the Medical Officer of Health (MOH) should be advised so that he in turn can warn the residents to boil the water from the tap before use.

   Immediately advise the Ministry of the Environment Regional Office for the area.

8. All events which occurred during the emergency must be recorded in the Operator's Daily Log Book.

IN CASE OF CHLORINATION SYSTEM BREAKDOWN IN A WATER TREATMENT PLANT

DO NOT *PUMP UNCHLORINATED WATER TO THE DISTRIBUTION SYSTEM. NOTIFY THE SUPERINTENDENT IMMEDIATELY. IF CHLORINATION SYSTEM CANNOT BE RESTORED TO WORKING ORDER IN TWO HOURS, NOTIFY THE MEDICAL OFFICER OF HEALTH AND THE REGIONAL OFFICE, MINISTRY OF THE ENVIRONMENT.*

ALARM SYSTEMS (CHLORINE DETECTION)

In chlorination, alarm systems are used primarily to warn the operator that chlorine is escaping or of an equipment failure of malfunction. Alarm systems can also be used to send local or remote signals, or to activate other equipment (for example, standby equipment, exhaust fans). The most common systems in use to detect chlorine in the atmosphere are sensitized paper* and a sensing cell system.

Sensitized Paper (See Figure 6-2) is darkened in the presence of chlorine. Its method of operation is as follows: A photo-electric cell picks up the reflected light from the sensitized paper. This is converted to an electrical current which opens a relay circuit to the alarm. When the sensitized paper is darkened in the presence of chlorine, the current to the relay drops. This closes the relay circuit and activates the alarm system.

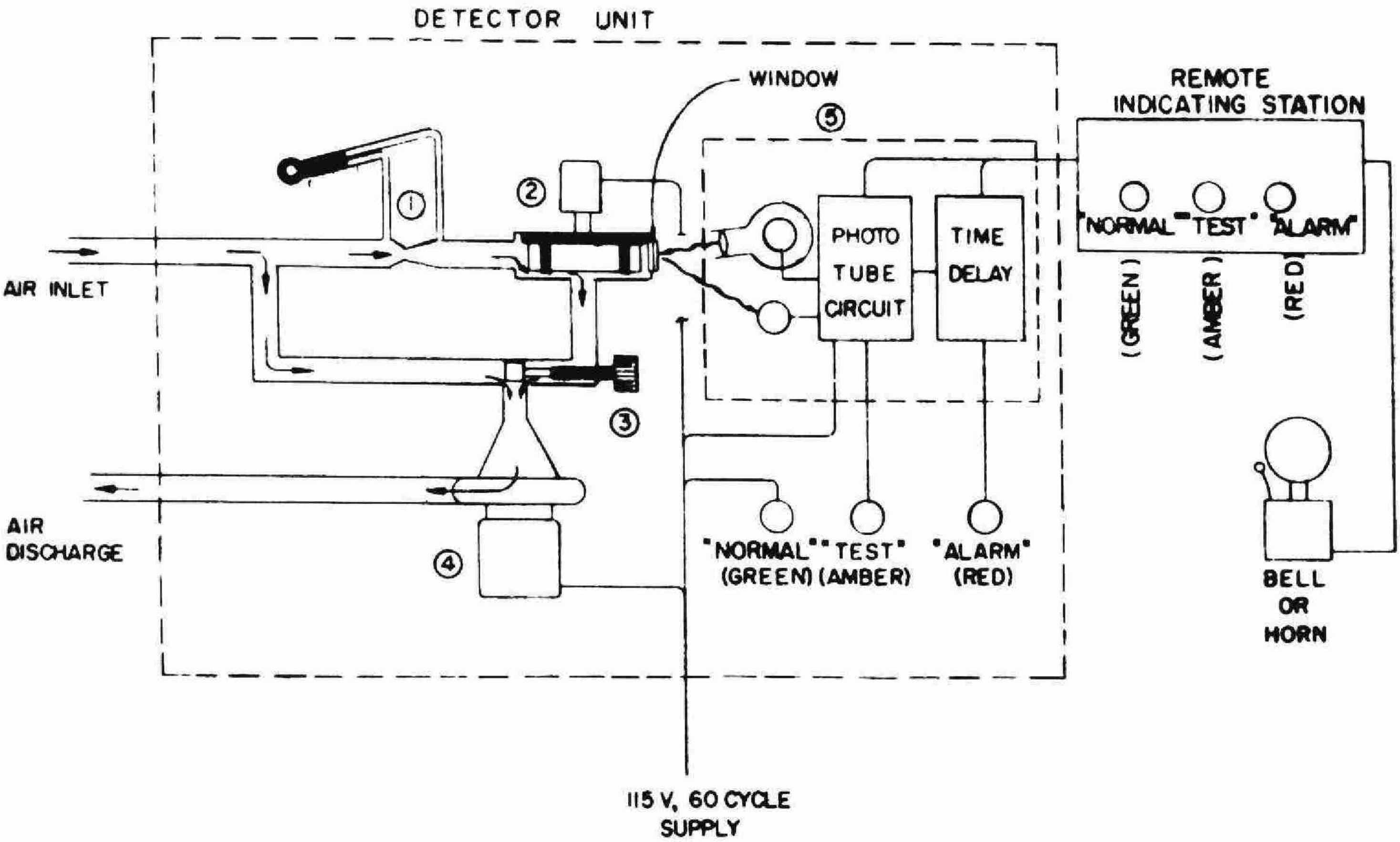
A sample of air is constantly pumped across the sensitized paper. The paper should be replaced daily, or whenever an alarm condition exists. Normal shelf life of the paper is approximately six months.

* *The sensitized paper detector has recently been taken off the market. However, the supply of sensitized paper will continue to be available.*

In the *sensing cell system* (Figure 6-3), a sample of air is drawn through a sensing cell. Any chlorine present in the air sample will increase the electric signal to an alarm circuit. When the electric signal reaches a pre-set point, the alarm system is activated and remains activated until the chlorine leak is repaired and chlorine is no longer present in the air sample. The electric signal generated by the sensing cell is reduced and the alarm circuit is deactivated.

When equipment failure or malfunction occurs, the alarm system is activated by the vacuum within the chlorinator. If the vacuum *increases* beyond the normal operating level, a diaphragm-operated switch activates the alarm system. Vacuum increase is caused by failure of the chlorine supply.

If the vacuum should *decrease* or drop below the normal operating level, the diaphragm-operated switch will activate the alarm system. Vacuum decrease can be caused by failure of the water supply, plugging of injector, increase in pressure downstream of the injector, or any leak in the vacuum system.



NOMENCLATURE

① AIR SAMPLE MEASURING ORIFICE & MANOMETER

② TEST CHAMBER WITH SENSITIVE TEST PAPER MOUNTED ON ½ RPM REVOLVING DRUM TEST CHAMBER IS EQUIPPED WITH WINDOW FOR PHOTOTUBE AND DOOR FOR ACCESS TO TEST PAPER WHICH MUST BE CHANGED DAILY

③ AIR SAMPLE FLOW ADJUSTMENT SET FOR 03 TO 04 CFM AIR FLOW THROUGH TEST CHAMBER

④ BLOWER

⑤ PHOTOTUBE AMPLIFIER CHASSIS WITH LIGHT SOURCE AND TIME DELAY CIRCUITS

Figure 6-2 ALARM SYSTEM (SENSITIZED PAPER METHOD)

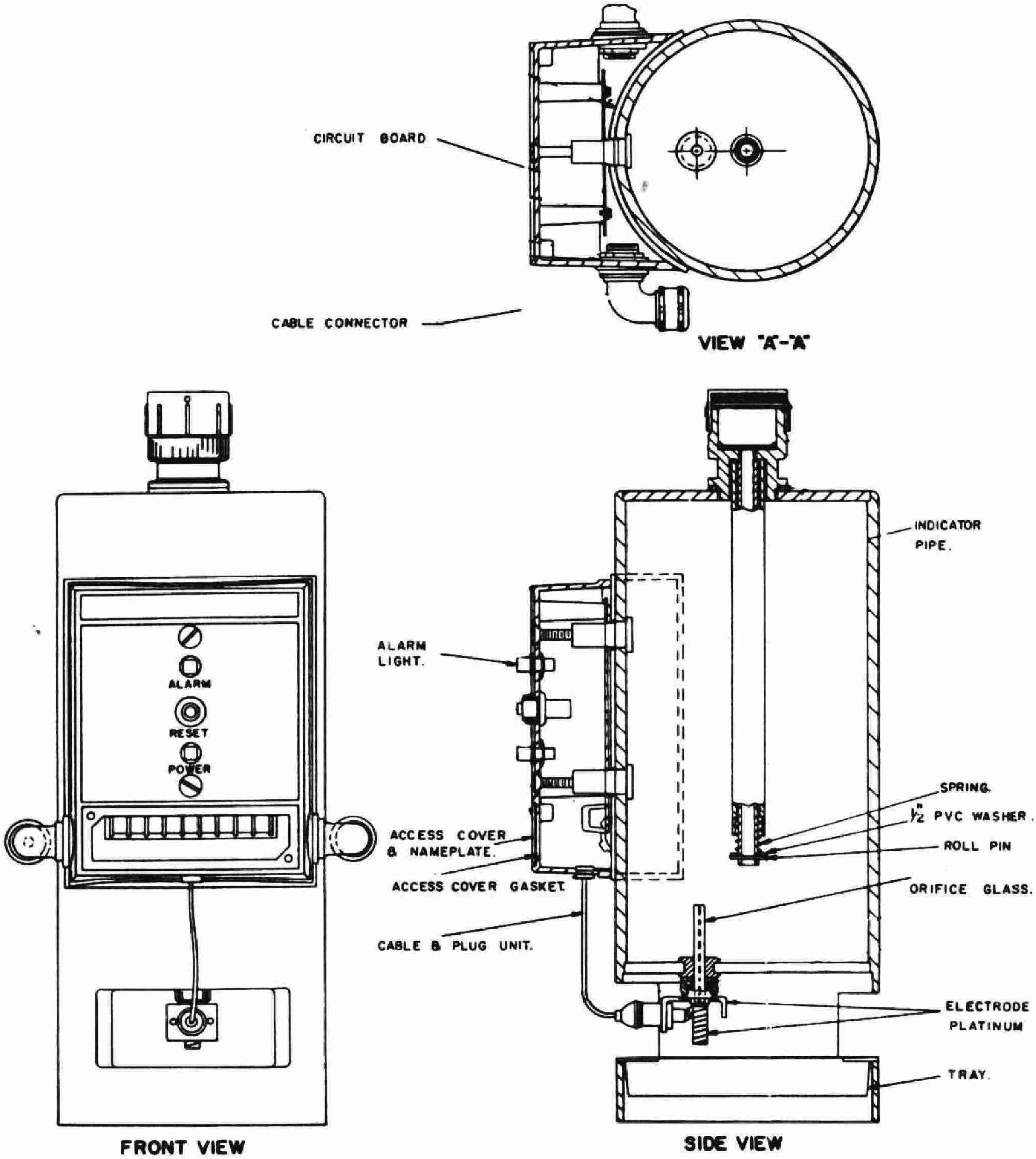


Figure 6-3 ALARM SYSTEM (SENSING CELL METHOD)

APPENDIX B

PERSONAL HYGIENE

For the sake of your health and the health of your family:

1. Never eat your lunch or put anything into your mouth without first washing your hands.
2. Do not smoke while working in tanks, on pumps, trucks, filters, etc. Remember, you inhale or ingest the filth that collects on the cigarette from dirty hands. Save your smoking time for lunch hours or at home.
3. Never put your hands above your collar when working on any plant equipment, if possible.
4. Don't wear your overalls or rubber boots to the dining area.
5. Always wear your rubber boots when working in tanks, around sludge, washing down, etc. Don't wear your street shoes.
6. Keep your street shoes in your locker. Remember: what your shoes pick up at the plant they will leave on the floor of your home.
7. Don't wear your coveralls or rubber boots in your car or home.
8. Have a complete change of clothing to wear when going home.
9. Always clean any equipment such as safety belts, harness, face masks, gloves, etc., after using. You or someone else may want to use it again.
10. Always wear rubber or plastic coated gloves when cleaning out pumps, handling hoses, or when working around the plant.
11. Avoid putting on gloves when your hands are dirty. Wash first.

12. Wash with plenty of water or take a shower immediately after being splashed with sludge, or any chemical. *DON'T DELAY.*

13. Don't just wash your hands before going home. Wash your face thoroughly too. There is more of your face to carry germs than there is of your hands.

14. Wear a hat when working around sludge tanks, filters, or cleaning out grit or other channels. Don't go home with your head resembling a mop that just wiped up the floor around a cleaned out pump.

15. Keep your fingernails cut short and clean - they are excellent carrying places for dirt and germs.

APPENDIX C

AIR PACKS

The-15 minute "Sac Pac" Air Pack

This unit should be put on and operational in 12-18 seconds.

To Put On (Refer to Figures 6-4 to 6-10)

1. All straps to be fully extended and the pack hanging on the wall by the metal grummet.
2. Grasp air regulating valve facing you and turn on at least one complete turn.
3. Place the air pack on your back by placing your left arm through the left shoulder strap, then the right arm through the right shoulder strap.
4. Adjust the two adjusting straps at your shoulders to set pack comfortably on your back.
5. Reach around with your right hand and open pouch (pocket) on the bottom of the pack and the face mask will drop out.
6. With left hand grasp face mask and put harness of mask to the back of head, pull mask down over face placing your chin in the recessed area just below the full face screen.
7. Adjust head straps starting from the bottom upwards to the top of the head; always adjust both head straps on each side of the head at the same time to guarantee centering of mask over face.

   YOU ARE NOW BREATHING FRESH AIR.

The 15-minute "Sac Pac" Air Pack is only an emergency unit and does not come with a low air pressure alarm, however an alarm can be obtained if desired.

To Remove Unit

1. Remove face mask.
2. Fully extend (spiders) head straps.
3. Remove pack from your back.
4. Fully extend shoulder straps.
5. Shut off air regulator valve and purge the air line with the by-pass button located on the face mask.
6. Replace face mask into the pouch with the by-pass button facing upwards and the full face screen facing outwards so the head straps are to the base of the air pack.
7. Close flap.
8. Place the air pack back on the wall on the grummet.

Always refill the air cylinders after every use.

The 30-Minute Air Pack

This unit will usually take at least 2 minutes to put on. It is a working unit as well as an emergency unit.

On the harness pressure guage the "Red By-Pass" valve must be closed and the "Yellow Demand" valve locked open at all times.

To Put On (Refer to Figures 6-11 to 6-16)

1. Ensure that all straps are extended.
2. Place air pack on back by placing left arm through left shoulder strap, then right arm through right strap. This should be done with your body slightly leaning forward to prevent air cylinder bottle from hitting your head. This also takes some of the weight off your shoulders.

3. Buckle the chest and waist belts and adjust pack to the most comfortable position on your back by the two small straps at your shoulders in front.

4. Fully open the air cylinder valve at the base of the cylinder. The harness pressure gauge should now read the cylinders air pressure.

5. Place face mask harness to the back of your head, pull mask down over your face placing your chin in the recessed area just below the full face screen.

6. Adjust head straps starting from the bottom upwards to the top of the head; always adjust both head straps on each side of the head at the same time to guarantee centering of the mask over the face.

7. Test face mask for air tightness by placing hand over hose end and taking a deep breath. If mask draws in around face, air tightness has been obtained.

8. Insert the hose end into the hole on the chest air gauge housing and hand tighten locking nut.

Air pack is now working.

A low air pressure alarm is activated when approximately 300 to 500 lbs. of air is left in cylinder. When alarm sounds, leave contaminated area immediately.

<u>To Remove Unit</u>

1. Remove procedure, shut off air cylinder valve, purge the system of air by opening red by-pass valve and then reclose it.

2. Extend all straps fully and replace air pack into holding case.

   Always refill air cylinder after every time used.

The 20-Minute Air Pack

This unit is put on over the head and rests on the right shoulder with the cylinder valve at the left hip. All other procedures are the same as the 30-minute air pack.

All air packs must have the by-pass valve shut off except when:

1. *purging system after use*
2. *demand valve fails*
3. *face mask leaks around eye glasses side frames*
4. *full face screen is fogging up.*

All air packs pressure gauges to be checked monthly to see that air cylinders are full and the air cylinders to be hydro-static tested every five years.

Canister-Type Gas Masks

Many operators of water and wastewater treatment plants are still using canister-type gas masks for protection when a chlorine leak occurs. This type of mask provides only limited protection, even under ideal conditions.

The canister contains activated carbon and filters out chlorine gas in the air by absorption.

Each time it is used in the contaminated air, its absorption capacity is reduced.

The number of times it can be used before the carbon becomes exhausted is not known.

Warning:

A canister type mask will give no protection when the oxygen in the air is too low to support life, whether it is brand new or used only once. The Ontario Ministry of the Environment has replaced all canister type masks with small, self-contained air packs.

APPENDIX D

FIRST AID

1. Remove patient from gas area. Patient should be kept in a warm room (about 21°C). Supply blankets under and over patient. Keep patient warm and quiet. Rest is essential.

2. Place patient on back. Place a folded coat, blanket, etc., under victim's shoulders so his head falls well back. This maintains a clear air passage to lungs of victim.

3. Call **for medical aid immediately.**

4. Promptly remove clothing contaminated with liquid chlorine, or chlorinated water. Keep patient warm with blankets.

5. A mixture of carbon dioxide and oxygen, with no more than 7% carbon dioxide, may be given. This mixture, already prepared and sold with the necessary apparatus, can be administered for periods of two minutes followed by two-minute rest periods for no longer than thirty minutes. Follow instructions of the gas apparatus supplier carefully. If carbon dioxide and oxygen mixture is not readily available, then oxygen alone may be used, or fresh air "Air Pack".

6. Milk may be given in mild cases as a relief from throat irritation.

7. If breathing seems to have stopped, immediately start "Mouth to Mouth" or "Revised Sylvester" methods of artificial respiration. *Do not exceed 17 to 18 movements per minute.* If possible, assist respiration with an inhalator or respirator. See page 6-23.

8. When eyes are irritated with chlorine, wash repeatedly with water and then with 1% boracic acid solution. Castor or olive oil drops may be used. In severe cases of eye contamination due

to chlorine, use bubbler fountain, hose, or eye cup. Irrigate for 15 minutes. A routine of 5 minutes irrigation and 10 minutes rest should then be followed for one hour. Prompt action is absolutely essential to protect eyesight.

9. Areas of the skin which have been splashed with liquid chlorine or chlorinated water should be repeatedly washed with water. After thorough washing, any burned area should be covered with a sterile dressing and bandaged snugly unless blisters are apparent; then bandage loosely.

If facilities are available, it is generally recommended that patients be removed to hospital as soon as possible, unless recovery from chlorine exposure is prompt and the exposure mild.

REVISED SYLVESTER METHOD OF ARTIFICIAL RESPIRATION

Lose no time in starting - delay can be fatal.

1. Clear mouth of any obstructions.
2. Lay casualty on his back.
3. Elevate shoulders of casualty with a folded coat, blanket, etc., so his head falls well back. This maintains a clear air passage to his lungs.
4. Place casualty's head between your knees and grasp his arms at the wrist.
5. Cross arms over the lower half of the breastbone and rocking forward, press firmly downwards (about 20 lbs. pressure), forcing air out of lungs of casualty.
6. Release the pressure by rocking back and pull his arms upwards, outwards and backwards. This extends the chest walls and draws air into the casualty's lungs.

7. Repeat cycle 12 to 15 times per minute until doctor arrives and says to stop, or until normal breathing is restored, or rigor mortis has set in.

ORAL RESUSCITATION

Lose no time in starting - delay can be fatal.

1. Clear mouth of any obstructions.
2. Lay casualty on his back.
3. Place a folded coat, blanket, etc., under victim's shoulders so his head falls well back. This maintains a clear air passage to his lungs.
4. Kneel beside casualty's head.
5. Pinch his nose and open your mouth wide and blow into his mouth strongly enough to cause the casualty's chest to rise.
6. Remove your mouth. Casualty's chest should fall.
7. Repeat cycle 12 to 15 times per minute until doctor arrives and says to stop, or normal breathing is restored, or rigor mortis has set in.

Artificial respiration must be continued until natural breathing is restored, a doctor says to stop, or rigor mortis sets in.

PROCEDURE USING 15-MINUTE PAC UNIT

Fig. 6-4 Sac Pac Unit can be hung on wall outside chlorine room.
Turn on cylinder air valve before putting unit on.

Fig. 6-5 Swing unit up and over left shoulder, then slide arm through right strap.

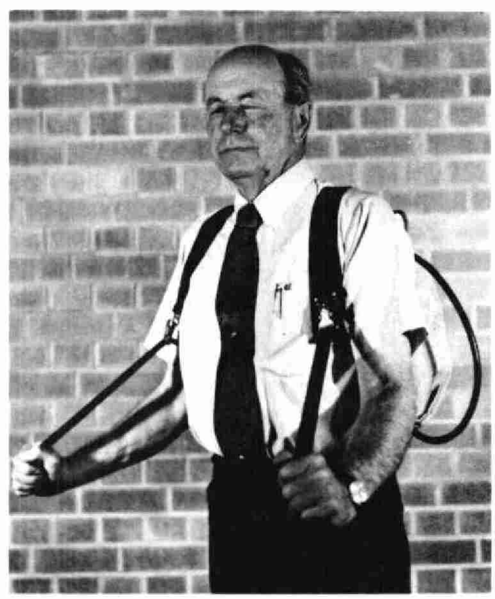


Fig. 6-6 Pull adjustment straps to tighten shoulder straps and secure unit to body.
Position unit on back so it is comfortable.

Fig. 6-7 Pull flap of facepiece cover with left hand.

Fig. 6-8 Face piece falls out to full length of hose.

Fig. 6-9 Put harness at back of head and pull mask down over face.

Fig. 6-10 Tighten head straps, starting with bottom straps on each side.

PROCEDURE USING 30-MINUTE AIR PAC

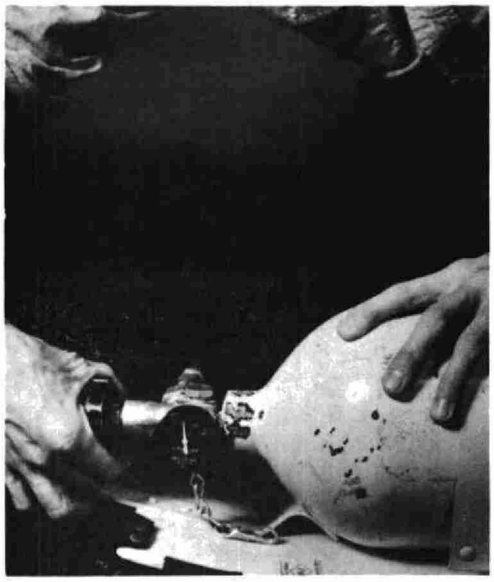


Fig. 6-11 Air valve can be turned on while Air Pac is in carrying case.

Fig. 6-12 Swing unit onto back, shoulder straps adjust so that cylinder rests in comfortable position on back.

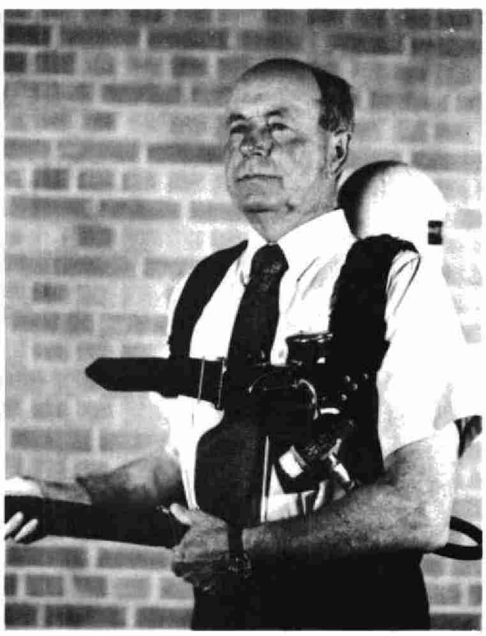


Fig. 6-13 Tighten chest and waist straps. (Newer Air Pac models do not have chest strap.

Fig. 6-14 See Fig. 7-6 for putting face piece on. Test for air tightness by blocking hose and drawing in breath.

Fig. 6-15 Attach hose to regulator.

Fig. 6-16 30-Minute Air Pac now ready for use.

SUBJECT: 3

CHLORINATION SYSTEM OPERATIONS

TOPIC: 7

STARTUP AND SHUTDOWN

OBJECTIVES:

The trainee will know and be able to demonstrate the proper procedures for starting up and shutting down the gas chlorination system.

START-UP AND SHUT-DOWN

GENERAL

Because of the hazardous nature of chlorine gas, it is essential that operators follow a fixed procedure for the start-up or shut-down of a gas chlorination system. Observing standard safety practices, together with a procedure which the operator has practised, will result in a minimum of injury-causing accidents or damage to the equipment.

Before entering the chlorine room or proceeding with the start-up or shut-down procedures, the operator should:

1. Check the condition of the air breathing unit nearest the entrance to the chlorine room. Is it full? Is it readily available for use?
2. Check the interior of the room by looking through the observation window for indications of possible leaks or hazardous situations.
3. Ensure that he is wearing gloves, safety goggles or face shield.

START-UP PROCEDURE

1. Before entering the room, turn on the exhaust fan. On entering the room
   a) check exhaust fan louvers (especially in winter) to make certain that they are open.
   b) for fans mounted in the ceiling or in the upper portion of the wall, or for externally-mounted fans, check for air suction by placing hand on the mouth of the duct. If there is no suction:
      (i) check to see if FAN is running;
      (ii) check ductwork for blockage.
   c) Check louvres on air inlet.

NOTE: Exhaust system (fan and motor) MUST be in operation at all times during start-up.

2. Visually inspect the following and ensure that the equipment is properly hooked up:

   a) Water lines: piping, elbows, valves, tees.

   b) Chlorination lines: piping, elbows, valves, tees.

   c) Vent lines: ensure they are not plugged and are vented to the OUTSIDE.

   d) Automatic control lines (if any): purge lines for possible moisture accumulation; in vacuum or pneumatic system, purge all air from pressure differential systems.

   e) Electric lines: make sure they are plugged into sockets.

   f) new chlorine lines: ensure litharge and glycerine or teflon tape has been used on pipe joints.

3. Open valve for water supply:

   a) listen for water "whistling" through injector.

   b) if no sound of water through injector, check water supply upstream.

4. Visually check the following for leaks:

   a) valves

   b) elbows

   c) piping

   d) connections

   e) if no leaks are apparent, proceed to Step 5.

5. Check to see if vacuum is obtained:

   a) Look at the vacuum gauge (if supplied) on the chlorinator; it should indicate a *vacuum* reading.

   b) If there is no vacuum (or if no gauge is supplied), disconnect vacuum line at the injector, place finger and listen for "pop" caused by vacuum (See Figures 7-1 to 7-4 for procedure).

6. Check that *ALL* valves between the chlorinator and cylinder(s) are *OPEN*. Turn handle to open as indicated on valve.

   WHY? To ensure purging of system in case of leaks.

7. Turn chlorinator feed control to any open position.

8. Crack open cylinder valve.

   WHY? If there is a bad leak in the system, the valve can be shut off quickly.

Place the wrench provided by the manufacturer on the valve stem, stand behind the cylinder valve outlet and, grasping the valve firmly with the left hand, hit the wrench a sharp blow in a counter-clockwise direction with the palm of the right hand. Do not pull or tug at the wrench as this may bend the stem, causing it to stick and, once opened, the valve may not close properly. *Do not under any circumstances use an ill-fitting manufacturer's wrench or a pipe wrench* since these wrenches will round the corners of the squared end of the valve stem. The manufacturer will gladly supply new wrenches on request. The use of large wrenches for opening stubborn valves should be avoided because, with the extra leverage obtained, there is danger of bending the valve stem or breaking it. To open a stubborn valve, follow the normal opening procedure but use a small block of wood held in the palm of the hand when striking the wrench.

Fig. 7-1 Unscrew (by hand) fitting in injector vacuum line.

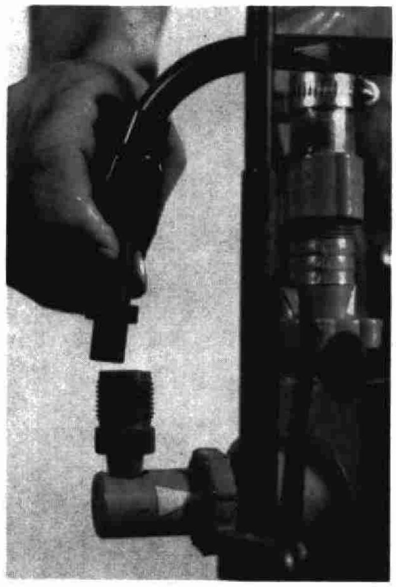


Fig. 7-2 Lift tubing from fitting.

Fig. 7-3 Place thumb over hole in fitting, hold for a moment.

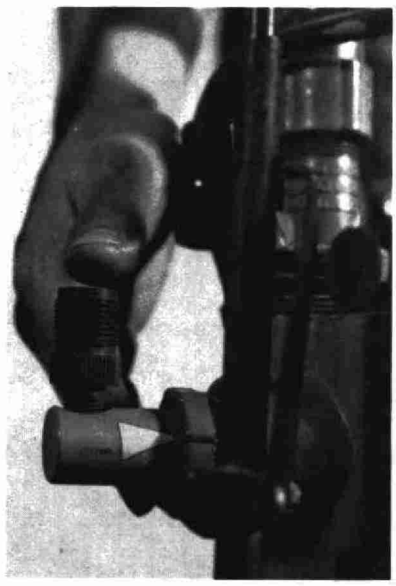


Fig. 7-4 Release thumb and listen for "pop" caused by vacuum. Reconnect tubing.

Immediately after the valve has been opened and the flow of chlorine adjusted, tighten the gland nut on top of the valve with the hand. Cylinders are shipped from the manufacturer with the gland nut slack so that the valve packing will retain its elastic properties until required for use. If chlorine is allowed to escape through the gland, the packing becomes hard and unserviceable.

9. Check chlorine pressure gauge. (See Figure 7-5) Approximately 40 psi should be recorded.

10. Turn chlorinator feed control to *CLOSED* position and observe chlorine pressure on gauge drop to zero.

11. Check for chlorine leaks (See Figures 7-6 and 7-7): Using a plastic squeeze bottle containing concentrated ammonia, check all joints and piping on chlorine line *by squeezing bottle under or close to chlorine joints and piping, exhausting the ammonia vapour from the bottle.*

    NOTE: A cloud of white smoke will indicate chlorine leak (caused by chlorine reacting with ammonia.

12. *If any leaks are found:*

    a) shut cylinder valve immediately,

    b) turn chlorinator feed control to MAXIMUM to purge system.

    c) *leave chlorinator room and shut door* until pressure gauge reads ZERO (usually a window in the wall allows you to see this from outside) and fumes are exhausted to atmosphere.

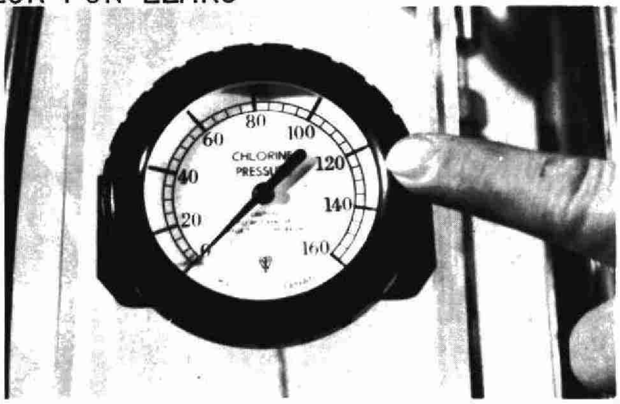
    d) when pressure gauge reads ZERO, proceed with corrective maintenance for leaks(s). (This may be tightening of joint, replacing leaky gasket, replacing valve, replacing split piece of pipe, etc.)

    NOTE: Loosen and tighten diaphragm valves by hand only.

START UP - CHECK FOR LEAKS

Fig. 7-5

Check chlorine pressure gauge for pressure.



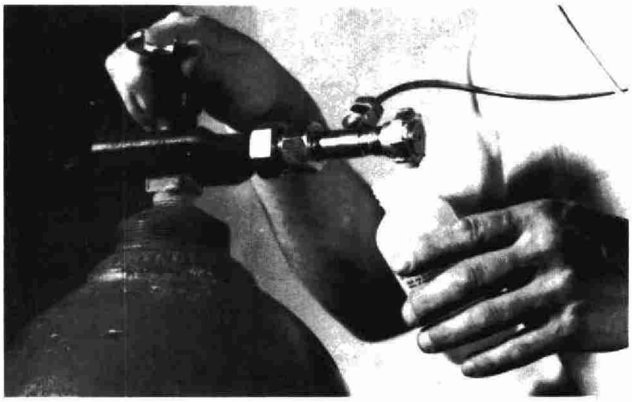
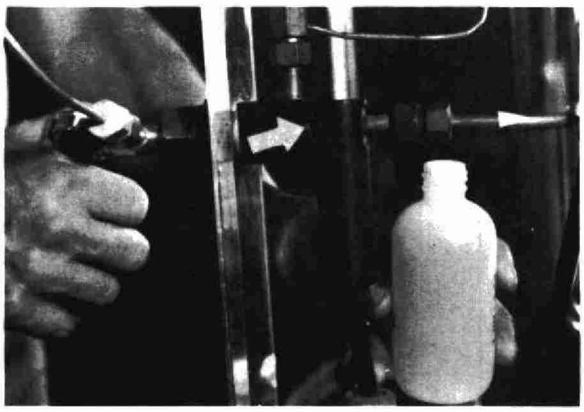


Fig. 7-6

Crack open cylinder valve, check for leaks at all joints with ammonia vapour.

Fig. 7-7

Check for leaks in chlorinator by using ammonia vapour.



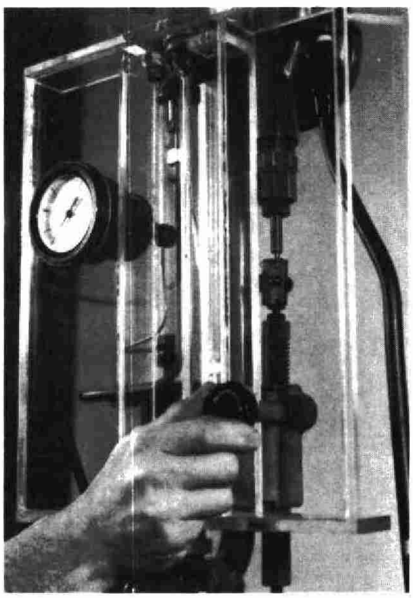


Fig. 7-8

If no leaks, adjust feed rate.

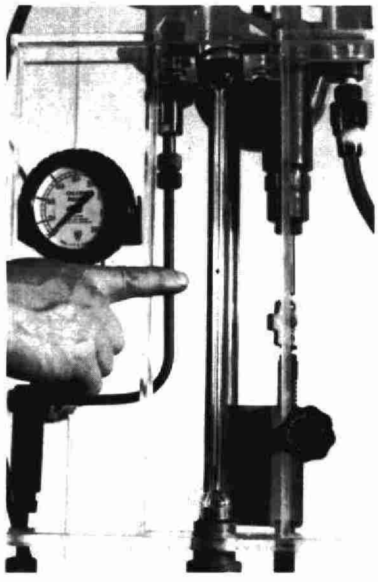


Fig. 7-9

Check ball in rotameter for feed rate setting.

13. When leak has been repaired:

    a) fully open the chlorine cylinder valve (1½ turns).

    b) *RETURN TO STEP 4 AND REPEAT STEPS 4 TO 11. IF NECESSARY, REPEAT STEPS 12 AND 13.*

14. *If no leaks are found:*
    Adjust the chlorinator setting to the desired rate (See Figure 7-8). Check ball in rotameter for feed rate setting (See Figure 7-9).

15. If chlorination system is MANUAL, then check-out is complete. If chlorination system is AUTOMATIC, check control components for proper functioning according to the manufacturer's specifications.

TABLE 7-1

SUMMARY: START-UP SEQUENCE
1. Start vent fan
2. Open water lines
3. Check chlorinator vacuum
4. Open cylinder and valves
5. Check for leaks
6. When leak-free, adjust chlorinator setting.

STARTING UP CHLORINATOR USING TWO OR MORE CYLINDERS

1. Carry out steps 1 through 7 described earlier.

2. Crack open the valve of the cylinder farthest from the chlorinator until approximately 40 pounds per square inch (psi) of pressure is recorded on the pressure gauge of the chlorinator.

3. Shut off the cylinder valve and test for leaks. If there are no leaks, wait until the pressure indicated by the gauge returns to zero.

4. *If the pressure gauge fails to record any pressure:*

   a) shut off cylinder valve immediately

   b) Crack open the valve of another cylinder and close it again in one continuous motion. If there is still no pressure, the feed pipe may be plugged or other operating problems exist. *Do not attempt to repair or make adjustments to any part of the chlorine system until the chlorine gas now trapped in the feed pipes from cylinder to chlorinator has been released.*

   c) Put on a self-contained air pack with full face piece, loosen one of the feed pipe connections and allow the trapped gas to escape *slowly* from the piping. Wait until the room has been cleared of all escaping gas to make the necessary repairs or adjustments.

5. When the problem has been corrected, crack open the valve of the cylinder farthest from the chlorinator.

6. Carry out steps 9 through 13 on pages 7-5 and 7-7.

7. Crack open the valve of the second cylinder and repeat the procedure used on the first cylinder; repeat until all cylinders being used have been tested.

8. After all cylinders have been tested, fully open the valve of the cylinder to be used first. Adjust the chlorinator setting to the desired rate. Check the rotameter ball for feed rate setting.

SHUT-DOWN PROCEDURE

1. Before entering the room, turn on the exhaust fan. On entering the room:

   a) check exhaust fan louvers (especially in winter) to make certain that they are open.

   b) for fans mounted on the ceiling or in the upper portion of the wall or for externally-mounted fan, check for air suction by placing hand on the mouth of the duct.

   c) if there is no suction:

      (i) check to see if FAN is running

      (ii) check ductwork for blockage.

NOTE: Exhaust system (fan and motor) MUST BE IN OPERATION AT ALL TIMES DURING SHUT-DOWN.

2. Shut OFF chlorine at cylinder or manifold as required. Check pressure gauge, making sure its reading drops to ZERO.

3. Beginning at cylinder(s):

   Shut off ALL valves as you move towards chlorinator, but

   DO NOT SHUT OFF CHLORINATOR YET.

4. Allow chlorinator to continue operating for approximately *15 minutes, without chlorine entering it.*

   WHY? To ensure complete purging of system.

5. Shut off water supply (injector) valve.

6. Shut off automatic control equipment such as electric plug positioner, variable vacuum valve, or pneumatic valves.

7. If system is shut down *longer than 10 minutes*, *ALL* chlorine lines must be sealed from atmosphere.

WHY? Chlorine mixing with moisture from the air will cause corrosion of pipe.

TABLE No. 7-2

CHLORINATOR SHUT-DOWN SEQUENCE
1. Start vent fan
2. Shut off cylinder(s)
3. Check chlorine pressure
4. Shut chlorine line valves
5. Shut water valves

SUBJECT: 3

CHLORINATION SYSTEM OPERATION

TOPIC: 8

MAINTENANCE

OBJECTIVES:

The trainee will be able to

1. Recall the checks which should be carried out daily, weekly and annually.

2. Recall the procedure for carrying out a maintenance check of

   a) The Exhaust Fan System

   b) The Injector

   c) Rate Controller

   d) Rotameter

   e) Pressure and Vacuum Gauges

   f) Alarm System

   g) Recording Instruments.

PREVENTIVE MAINTENANCE

GENERAL

To ensure trouble-free operation to the maximum degree possible and to minimize the cost of maintenance service by the equipment suppliers, a comprehensive preventive maintenance program is essential. The following paragraphs suggest checks which should be carried out on the gas chlorination system on a daily, weekly and annual basis.

Daily Maintenance

1. Check that the air pack(s) are available and serviceable.
2. Check that the exhaust fan system is operating properly.
3. Visually check
    a) Position of ball in rotameter.
    b) All pressure/vacuum gauges.
    c) Recording instruments to ensure that they are operating.
    d) The residual analyzer reading.
    e) Pump and all piping for evidence of corrosion.
4. Check temperature, pressure and water level of evaporator (if installed).
5. Check and record weigh scale reading.

Weekly Maintenance

1. Clean screens and strainers on waterlines by removing them from the lines and flushing with clear water.
2. Operate all shut-off and rate control valves to ensure proper functioning.

3. Check chlorinator vent line(s) to ensure that it (they) are not blocked.

4. Check functioning of the alarm system.

5. Check ink supply for recording charts.

Annual Maintenance

1. Disassemble injector. Clean components; replace gaskets, diaphragms or other parts as necessary.

2. Remove and check other components. Replace parts and packing as necessary.

3. Replace all metal chlorine gas piping leading from the cylinders to the header or chlorinator. These should be replaced after each season of use or at least once a year.

   NOTE: DO NOT ATTEMPT TO CLEAR AND REUSE PIPING. ALL BLACK IRON PIPE USED AS HEADER PIPE FOR GAS OR LIQUID CHLORINE SHOULD BE REPLACED AFTER 5 YEARS OF SERVICE.

4. Touch up all metal parts with paint.

Component Maintenance

The following describes what the operator should do when carrying out the maintenance checks on the equipment listed below:

1. Exhaust Fan System

   a) Turn fan off and on to check fan operation.

   b) Turn fan off. Lock it out and tag the switch. Check fan blade for play in bearings.

   c) Turn fan on. Check fan louvers for proper operation.

   d) Check exhaust and air inlet duct work for possible blockages.

2. Injector

a) Disassemble injector.

b) Check nozzle (throat) for plugging by rust, or accumulation of dirt. Remove blockage.

c) Check tailway (discharge section) of injector for abrasion (particularly true when on wells or where some fine sand may be in suspension in water).

d) Inspect ball check - SHOULD BE CLEAN AND FREE TO MOVE.

e) Inspect diaphragm for breakage. If broken, replace.

f) Visually inspect for leaks at joints.

g) Replace gaskets where required.

h) Tighten bolts where required.

i) Check springs for corrosion or distortion.

3. Rate Controller

a) Inspect for possible linkage disconnection, or rack and pinion failure, stripped gears, broken shaft. (Operator must get in behind chlorinator to look. *Chlorinator should not be installed too close to wall.)*

b) Operate controller by hand to see if gas flow can be regulated (increased or decreased).

c) Check all seal gaskets and replace if necessary.

d) Check for foreign material on stem and seat.

e) Check automatic control by using manufacturer's procedures manual. (If chlorinator functioned satisfactorily on manual control, problem may be in the automatic control.)

4. Rotameter

a) See if there is any build-up of foreign material inside rotameter and/or on the FLOAT.

b) Make sure that rotameter is properly seated at top and bottom. (See Fig. 8-1)

WHY? If rotameter is off-centre, a vacuum leak may be created, leading to faulty operation.

c) Inspect gaskets for defects (cracked or flattened). Replace if required.

5. Pressure and Vacuum Gauges

a) Check for leaks.

b) Open line at joint and check for plugging.

c) Open gauge by removing glass and dial face. Check gearing for wear.

NOTE: Do NOT disconnect gauge from its diaphragm assembly.

d) Check bellows for possible rupture (oil at connection to tube).

6. Evaporator

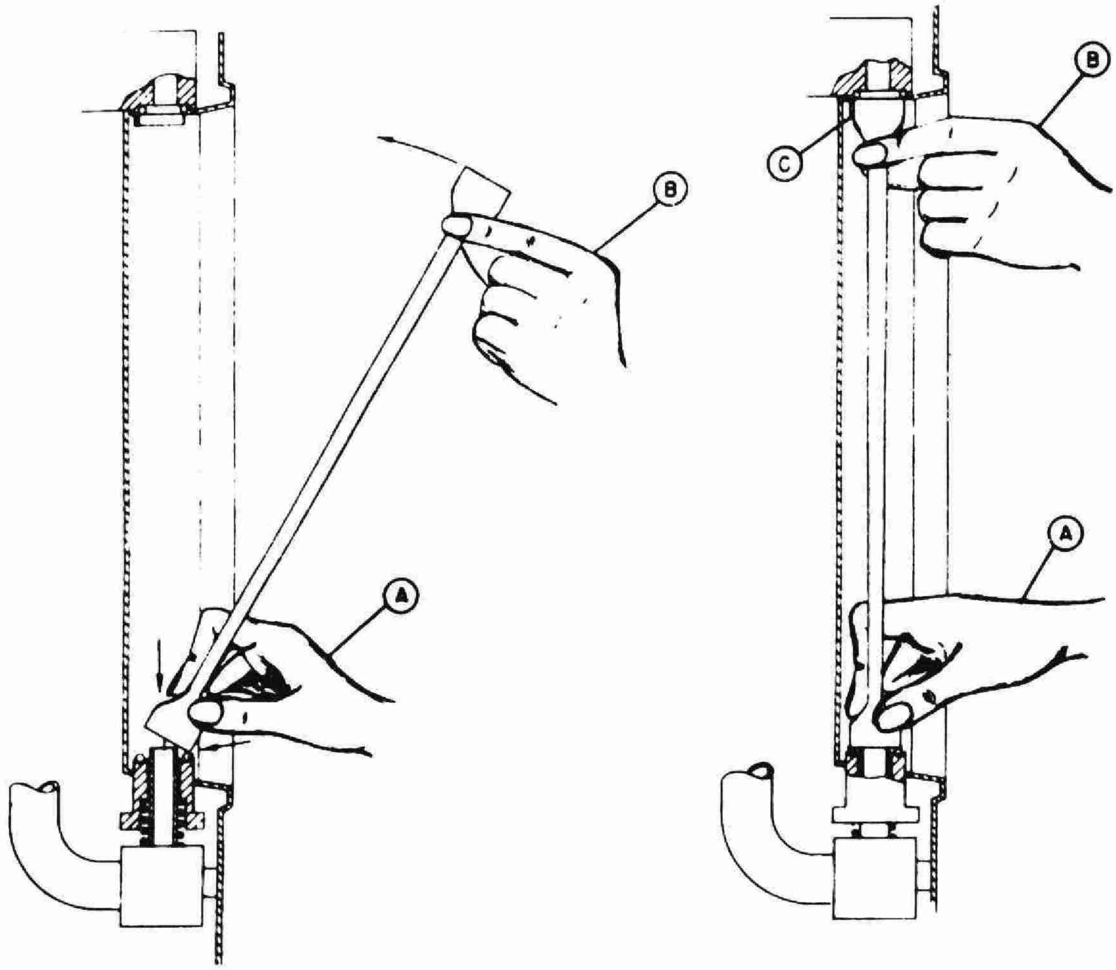
a) Check temperature:

(i) If it is *HIGH* (approx. 70°C), shut off power supply to heaters.

(ii) If it is *LOW* (approx. 50°C), check to see if heater is functioning, or if it is burnt out.

b) Check water level - *SHOULD BE WITHIN LIMITS SET BY MANUFACTURER:*

(i) If *LOW*, check "make-up" valve. If valve is manual, open it. If valve is automatic, it may need repair. Low level may also be caused by evaporation. Pour light film of oil over surface to prevent evaporation.



TO INSTALL ROTAMETER--

1. *LUBRICATE BOTTOM "O" RING ONLY WITH A LIGHT FILM OF SILICONE GREASE.*
2. *POSITION "O" RINGS AS INDICATED. INSERT FLOAT AND STOPS IN ROTAMETER TUBE.*
3. *GRASP ROTAMETER BY THE TWO ENDS.*
4. *GUIDE LOWER END OF ROTAMETER WITH HAND "A" TO LOCATE ON "O" RING.*
5. *EXERT DOWNWARD FORCE WITH HAND "A" TO COMPRESS SPRING AND USE TWO FINGERS OF HAND "B" TO GUIDE TOP OF ROTAMETER INTO POSITION. ROTAMETER MUST TOUCH AT POINT "C" TO INSURE SEATING ON UPPER "O" RING.*
6. *RELEASE DOWNWARD FORCE ON SPRING.*

TO REMOVE ROTAMETER--

1. *EXERT DOWNWARD FORCE ON LOWER BELL OF ROTAMETER WITH HAND "A."*
2. *USE TWO FINGERS OF HAND "B" TO SWING TOP OF ROTAMETER OUTWARD.*
3. *LIFT ROTAMETER.*

READ SCALE OPPOSITE CENTER OF BALL

Figure 8-1   ROTAMETER INSTALLATION

(ii) If *HIGH*, drain water to level required and be sure "make-up" valve is closed. (Leaking make-up valve causes high level).

c) Check pressure:

(i) If pressure is *HIGH*, check high temperature control to see if it is functioning, because high pressure is caused by high temperature.

(ii) If pressure is *LOW*, check chlorine supply which may be low. Increase chlorine supply. Change cylinder if necessary. Check to see if thermostat is turning on heaters at LOW temperature.

(iii) Check incoming liquid pressure and be sure it is at proper level.

7. Alarm System

a) Chlorinator Malfunction.

Check functioning of system by:

(i) Turn off water to injector and wait for alarm to sound (approx. 15-20 seconds); when alarm rings, turn water on again; if alarm does NOT sound, check linkage to switch, then check diaphragm.

(ii) Turn off chlorine gas supply and wait for alarm to sound; when alarm rings, turn chlorine supply on again; if alarm does NOT sound, check linkage to switch, or positioning of switch.

NOTE: Alarm system should be checked at least once a week.

b) For atmosphere in chlorination room:

(i) If alarm system uses sensitive paper, use finger to block light to sensitized paper; listen for alarm to sound; remove finger blocking light.

NOTE: Be sure sensitized paper is not too old, as it loses its sensitivity to light with time. SHELF LIFE - 4 TO 6 MONTHS (IF KEPT AWAY FROM LIGHT).

(ii) Systems using a cell assembly can be tested by holding a beaker of Javex near the air intake. This should activate the alarm. System should slowly return to normal operation after removal of beaker.

8. Recording Instruments: Charts and Pens (See Fig. 8-2)

a) Check if chart is bent, misaligned or jamming as it rotates.

b) If pen does not print:

(i) Inspect ink-well to see if ink supply is gone.

(ii) Fill well as required.

(iii) Capillary tube may be plugged - run fine wire (4/1000 inch) through tube to remove foreign material.

(iv) Pen not touching paper. Check arm of pen to see if it is bent.

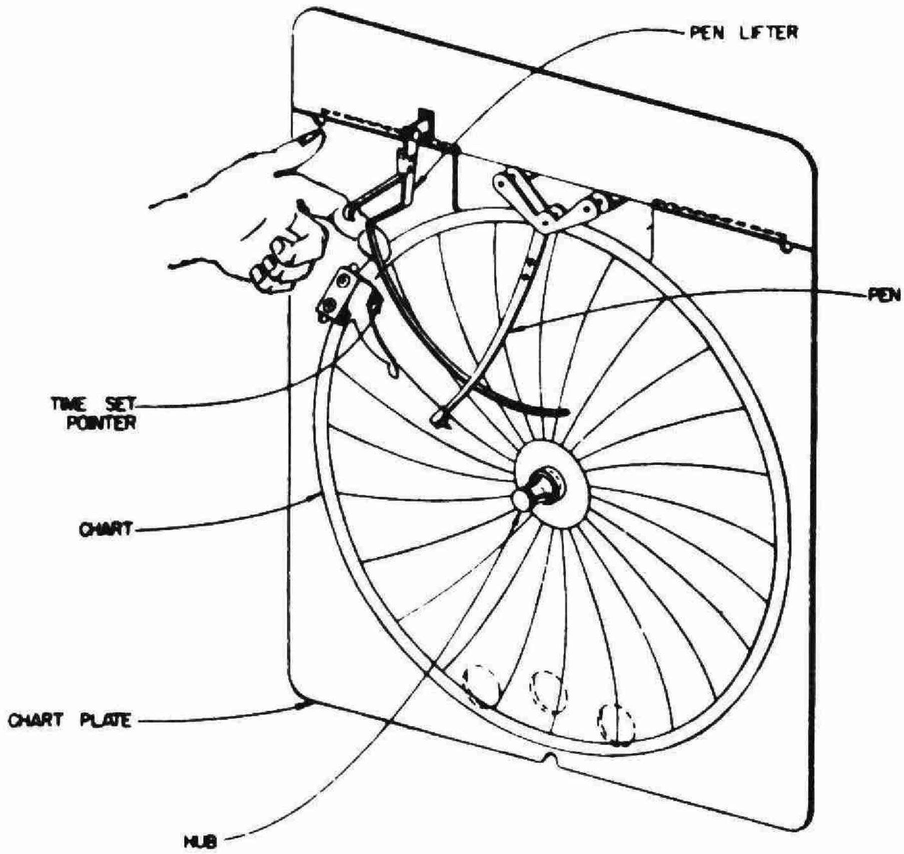
c) Fill through the tip with the plastic ink bottle as shown in Figure 8-3. This method of filling insures against air bubbles or other obstruction, and also primes the pen for quick starting. Put in no more ink than is estimated necessary. If there is doubt, a clean pen may be filled full the first time, but after that, the ink level should be kept as low as possible for cleanest lines and shortest drying time.

After using the plastic ink bottle wipe the spout and replace it tightly in the sealing hole in the bottle cap.

① *RAISE THE PEN LIFTER*

② *PULL OUT ON THE CHART HUB. IT WILL COLLAPSE INTO ITSELF, LEAVING THE CHART FREE TO COME OFF. REMOVE THE CHART.*

③ *PUT ON A NEW CHART. PUSH IN ON THE CHART HUB SO THAT IT REENGAGES THE CHART.*



④ *ROTATE THE CHART HUB UNTIL THE PROPER TIME ARC IS INDICATED BY THE TIME SET POINTER. (NOTE---DAY AND NIGHT SECTIONS ON THE CHART) THE TIME SET POINTER AND THE PEN POINT REGISTER ON THE SAME TIME ARC.*

Figure 8-2 CHART PLATE MAINTENANCE

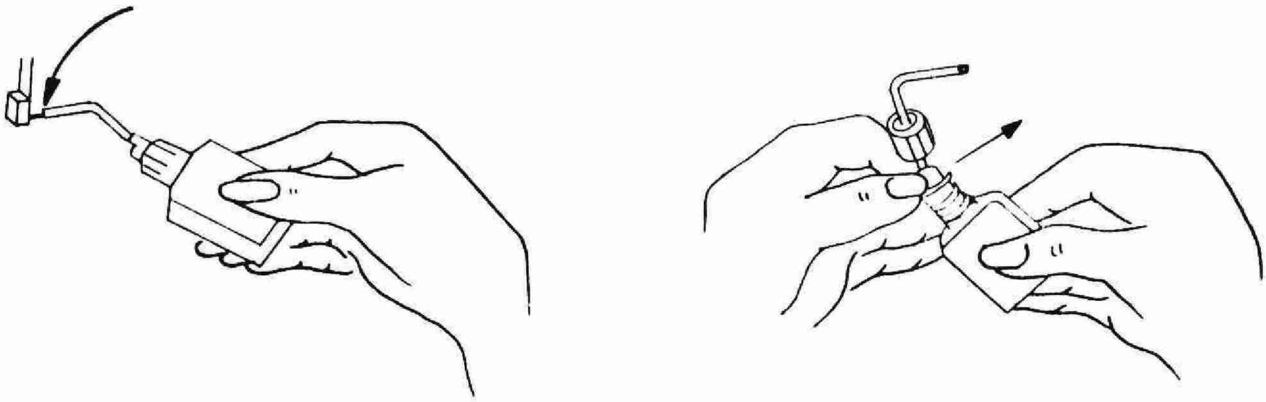


Figure 8-3 INKING A BOX PEN

d) Starting a Stubborn Box Pen

If trouble is encountered in getting a box pen to ink, proceed as follows:

(i) Remove the pen from the pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction permitting the clip on the back of the pen to be slipped off the pen-arm.

(ii) Fill the pen nearly full of ink.

(iii) Grasp the pen reservoir with the thumb on top and forefinger beneath, and squeeze. Ink should start to ooze from the pen tip.

e) Maintenance of Pen

If the pen becomes dirty or begins to skip, clean it as described below. Detergent cleaners may be used, but every trace should be removed or severe feathering may result. Use only recorder ink. If long service wears a pen so that the line is too wide, replace the pen.

d) To Clean a Clogged Box Pen

(i) Remove the box pen from its pen-arm. To do this, hold the pen-arm firmly and turn the pen in a counterclockwise direction. This permits the clip on the back of the pen to be slipped off the pen-arm. Carefully withdraw the pen from the hole in the pen-arm.

(ii) Run a wire not larger than 0.005" diameter (B&S Gauge #36 or higher) or a Cleaning Wire, Part P-26488, through the tip to push out the dried ink.

(iii) Flush out by filling through the tip with the plastic ink bottle. Force through a surplus of ink into a tissue or paper towel to make sure the tip is clean.

(iv) Replace the pen.

SUBJECT: 3

CHLORINATION SYSTEM OPERATIONS

TOPIC: 9

TROUBLE SHOOTING

OBJECTIVES:

The trainee will be able to recall and demonstrate the procedure for identifying and overcoming problems which arise when operating a chlorination system by knowing

1. the likely problem area,
2. what to check and sequence,
3. corrective measures.

CHLORINATOR TROUBLE SHOOTING

When a plant effluent is found to contain little or no chlorine residual, it is necessary to do a systematic check of the chlorination equipment.

The first item to check on any type of gas chlorinator would be the feed rate indicator. In the majority of instances (although not always) this will indicate in which half of the chlorinator you may locate the problem. The halves of the chlorinator being (a) from the chlorine cylinder through the pressure regulating valve to the feed rate indicator, (b) downstream of the feed rate indicator - between it and the injector.

Examples:

Problem #1 - A feed rate is indicated on the chlorinator.

- Low or Zero residual in the "treated" water.
- Normal pressure indicated from the chlorine cylinder.

Due to the feed rate being indicated on the ball or float of the chlorinator, you may usually assume that the system is normal at all points between the indicator and the injector.

If the chlorine is shut off at its source, the pressure may drop very slowly or not at all, but the ball will remain in a position indicating a chlorine feed. This would indicate a vacuum leak in the system between the point at which the chlorine enters the unit and the rate indicator, or in the vacuum half of the pressure-vacuum relief system.

Problem #2 - No feed rate indicated.

- No residual in "treated" water.
- Normal pressure indicated from Cl_2 cylinders.

The first thing to check in the above situation is whether or not you do have a vacuum at the source. If not, check for plugging of throat or injector, water pressure failure, excessive back pressure due to partial blockage of solution lines, etc.

If a normal vacuum is found at its source, you should make progressive checks in the system following the flow pattern back to the indicator until the vacuum leak is found.

When troubleshooting a chlorinator that is on automatic control *the first thing to do is put the unit on manual control.* It is almost impossible to locate a problem in a chlorinator set up in the automatic position.

It is necessary, in many cases, to have the gas pressure turned on to the chlorinator when troubleshooting. This can be done with little danger of gas escaping to the atmosphere *provided that NO JOINTS OR UNIONS IN THE METAL PIPING ARE DISTURBED.*

Chlorine is *under pressure in the metal piping only,* and all plastic parts contain a vacuum. Therefore, air will be drawn into the plastic piping from atmosphere if a connection is separated, with no harm to you or the equipment.

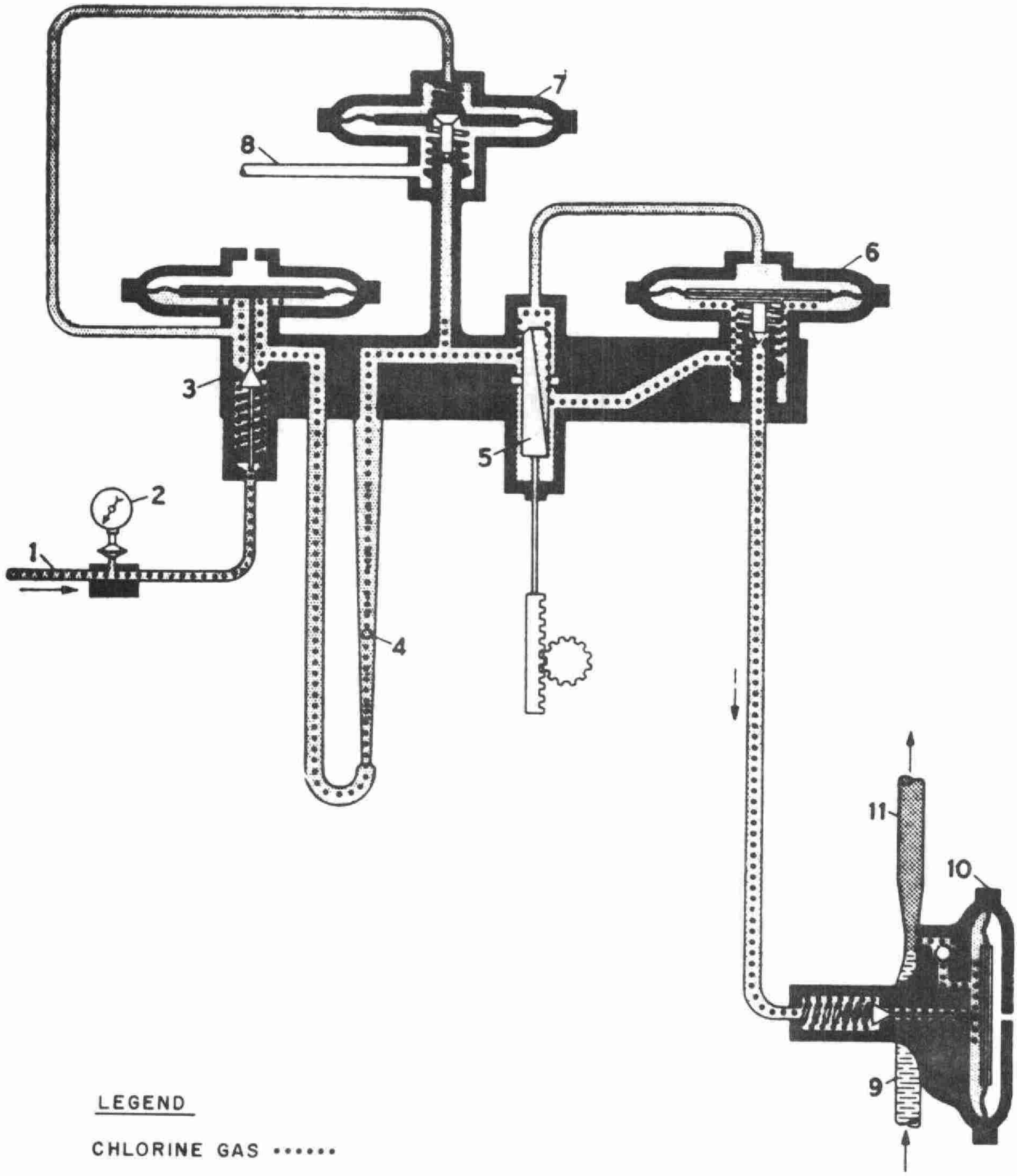
The following is a list of common problems, symptoms to look for and suggested remedies. Refer to Figure 9-1, 9-2 and 9-3 on pages 9-7, 9-8 and 9-9.

Chlorinator Symptoms	What is Probably Wrong	Auxiliary Checks	How to Remedy Symptoms
Manual chlorinator will not come up to full feed. Gas pressure adequate.	Insufficient injector vacuum	Measure operating water pressure just upstream of injector and back pressure just downstream of injector data. Check piping for smooth flow immediately downstream of injector tailway. (No elbows, tees, reducers, etc.) Check for air leaks through diaphragm of diaphragm-type injector check valves. Where injector vacuum is marginal or hydraulics are borderline, V-Notch differential is a <u>more</u> sensitive indicator of adequate operating vacuum than the injector vacuum gage. A "bobbing" rotameter float indicates marginal vacuum.	Clean injector throat and tailway. Clear or replace solution discharge tubing. Provide adequate operating water pressure. Note: A larger throat and tailway may only compound the problem as the greater flow creates more back pressure.

Chlorinator Symptoms	What is Probably Wrong	Auxiliary Checks	How to Remedy Symptoms
Manual chlorinator feeds OK at high rates, but will not control at lower rates.	CPRV not throttling sufficiently. (Held open by a particle of rust, ferric chloride, etc.)	Note especially if vacuum falls at lower feeds. If it does either air or chlorine must be causing it. To find out which, turn off gas at cylinder. If rotameter float drops, it was excess gas coming in. If turning off gas does not cause float to drop, air must be leaking in. Then close off vent opening. If float drops air was leaking through the diaphragm. If closing the vent has no effect then air is leaking past a gasket.	Clean CPRV cartridge. Check CPRV diaphragm for "pin hole" leaks. Check CPRV gaskets. On "2-valve" machines, check pressure relief stem, seat and spring condition. Clean or replace parts as necessary.
	-OR- Possibly a bad diaphragm in the differential valve is causing bypassing of the V-notch control valve.	Pressurize top of differential valve with air and check for leaks in water.	Replace diaphragm on 2000# or 8000# units. Replace valve capsule on lower capacity machines.

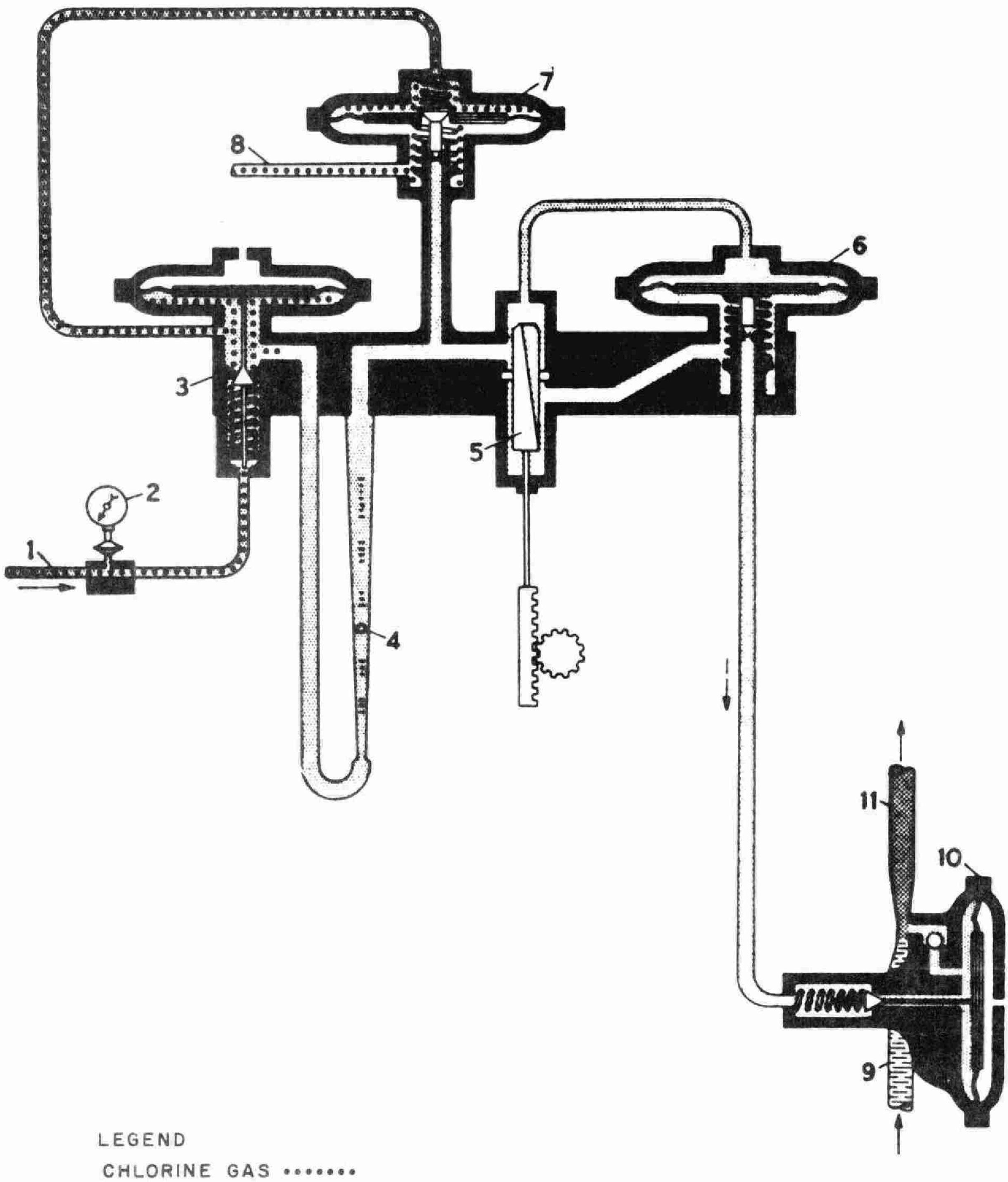
Chlorinator Symptoms	What is Probably Wrong	Auxiliary Checks	How to Remedy Symptoms
Manual chlorinator controls OK at low feeds, but is erratic when full feed is attempted. Injector vacuum OK.	Not enough chlorine entering to satisfy demand. Dirty CPRV cartridge or partially clogged gas line.	Check gas supply pressure. See if air is entering vacuum relief port at high feeds. Check vacuum relief level.	Clean CPRV cartridge. Clean high pressure gas line. Supply adequate chlorine gas pressure (20 psi is the minimum full feed performance - except on low rate apparatus).
Chlorinator does not feed anything. Gas pressure is adequate. Injector vacuum is OK.	Tube connection from upstream of V-notch to top of differential valve is disconnected or leaking.	On automatic machines make sure V-notch plug is not remaining in closed position.	Re-connect tube line. Replace tube if cracked, kinked or defective at ends. Tighten tube nuts.

Chlorinator Symptoms	What is Probably Wrong	Auxiliary Checks	How to Remedy Symptoms
A variable vacuum control chlorinator, formerly working normally now won't go below, say, 30% feed. Signal levels OK.	CPRV not throttling sufficiently for low feeds. (Held open by a particle of contaminant on seat or stem.)		Clean CPRV cartridge. Re-adjust bias spring at about 20% feed after reassembly.
A variable vacuum control chlorinator reaches full feed OK but won't go below, say, 40 to 50% feed. CPRV is OK.	Signal vacuum too high because of air leak by-passing restrictor through diaphragm of control vacuum check valve.	Air-tight quality of control vacuum check valve diaphragm. Check gasket and stem in diaphragm. Check felt filter disc for restriction due to dirt or moisture accumulation. Check converter flapper. and nozzle for freedom from dirt or restriction.	Replace diaphragm, gasket or stem as tests indicate source of leak. Clean and dry or replace filter disc.
A variable vacuum control chlorinator refuses to go to full feed. Gas pressure adequate. CPRV is clean. Injector vacuum is OK.	Signal vacuum too low because of plugged restrictor in control vacuum check valve -OR- air leaking into signal line.	Check connecting line from signal converter to chlorinator. Pressurize with air and use soap solution or submerge in water and look for bubbles. As an alternate, trap air under pressure and observe a T'ed-in vacuum gauge. Fall of pressure indicates a leak. Check joints, fittings, tube ends, retainer nuts, etc.	Remove and clean restrictor. Use solvent and a wire smaller than its .009 bore. Use teflon tape on threaded joints. Correct any vacuum leaks in signal lines. System must be "dead tight" due to very limited capacity of restrictor orifice.



1. chlorine inlet pipe
2. pressure gage
3. pressure-regulating valve
4. feed-rate meter
5. orifice
6. vacuum-regulating valve
7. relief valve
8. safety vent
9. water supply pipe
10. chlorine inlet valve
11. solution pipe

Figure 9-1 NORMAL OPERATION



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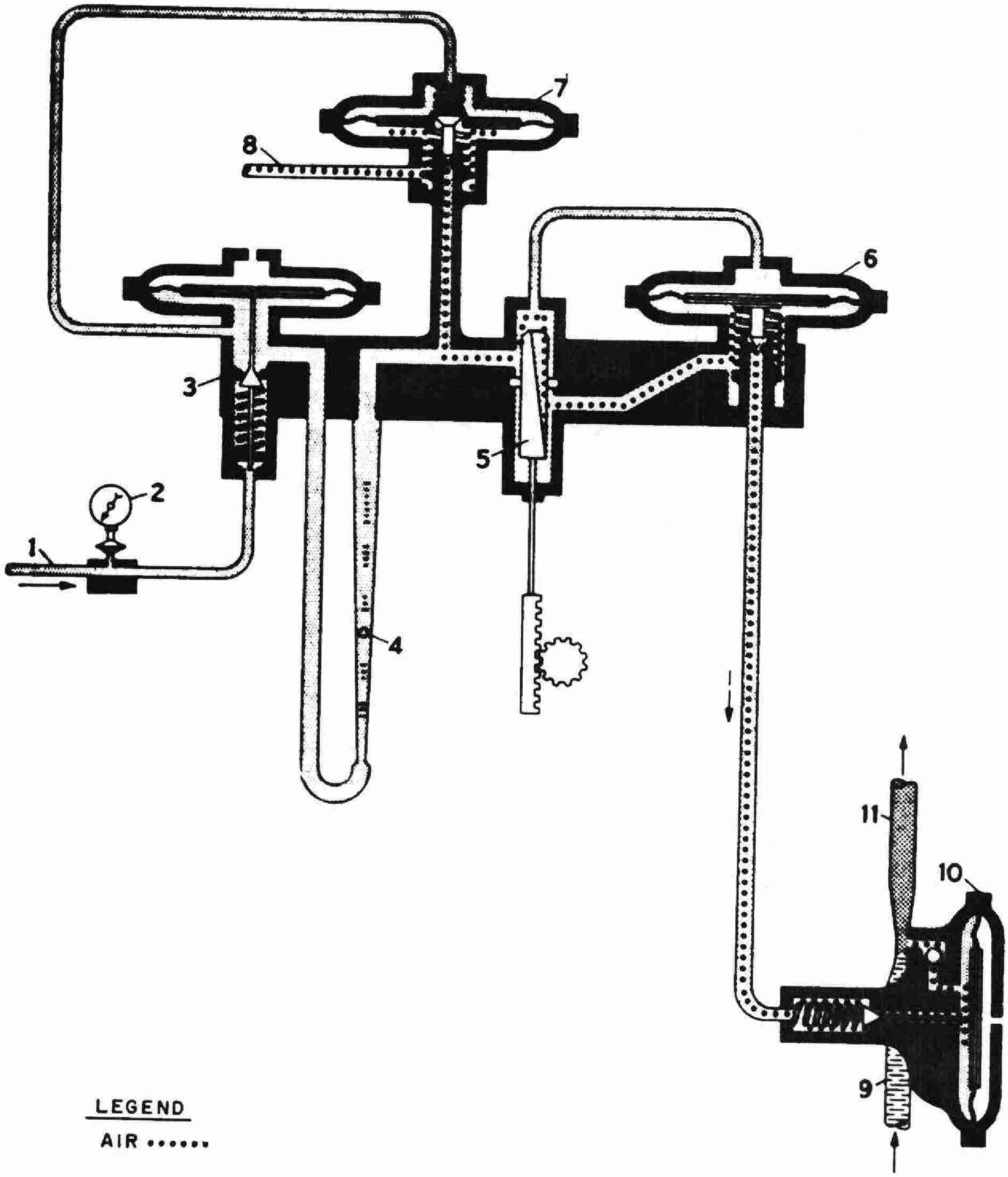
11. solution pipe

Figure 9-2 PRESSURE RELIEF



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5. orifice
6. vacuum-regulating valve
7. relief valve
8. safety vent
9. water supply pipe
10. chlorine inlet valve
11. solution pipe

Figure 9-3 VACUUM RELIEF

SUBJECT:

CHLORINE TESTING PROCEDURES

TOPIC: 10

- DPD METHOD
- ORTHOTOLIDENE TEST

OBJECTIVES:

The trainee will be able to:

1. Demonstrate and carry out the procedures for determining the chlorine residual using the DPD method with the Nesslerizer and Comparator.

2. Determine the chlorine residual of a given sample using the Orthotolidene Test.

CHLORINE TESTING PROCEDURES

DPD METHOD

Principle of the Method

Research in chlorine chemistry has resulted in the development of a very simple procedure for the determination of its free and total residual. With the new method differentiation between the combined forms of chlorine is also possible using the DPD indicator. The test has a high precision and accuracy and when properly used it can be an excellent aid in the control of chlorine residual at a water treatment plant.

A good feature of the Lovibond Comparator method lies in its use of compressed tablets which are convenient to handle, more stable than the DPD solution, and is a procedure of exceptional simplicity. In a recent investigation by the Water Research Association this method was judged the BEST COLORIMETRIC METHOD for the measurement of chlorine and chloramines in water.

Equipment and Reagents Required

1. DPD tablets for Comparator and Nesslerizer
   a) Nos. 1 & 3 together for total chlorine residual.

   b) No. 1 for free chlorine.

2. Comparator with Standard Lovibond Discs

   a) 3/40A disc covers the range 0.1 to 1.0 mg/l chlorine.

   b) 3/40B disc covers the range 0.2 to 4.0 mg/l chlorine.

   These discs require 13.5 mm. cells or test tubes. A dulling screen must be used.

3. Nesslerizer with Disc

NDP covers the range 0.05 to 0.5 mg/l. This disc must be used with a dulling screen and 50 ml tubes.

Procedure

1. Comparator

a) Determining Total Chlorine Residual

(i) Place a 13.5 mm cell or test tube containing sample only in the lefthand compartment, behind the colour standards of the disc.

(ii) Rinse a similar cell with the sample, and fill the cell or tube up to the mark with it.

(iii) Into this cell or tube drop one No. 1 and one No. 3 tablet (or one No. 4 tablet, which is No. 1 and No. 3 combined.

(iv) Allow tablets (or tablet) to disintegrate until effervescence ceases.

(v) *Mix rapidly* to dissolve the remains of the tablet.

(vi) Place the cell in the righthand compartment of the Comparator.

(vii) *After 2 minutes,* match the cells by holding the Comparator facing a good source of diffused north daylight and *revolve this disc until the correct standard is found. NEVER LOOK INTO THE SUN.*

(viii) The figure shown in the indicator window represents mg/l of *total chlorine residual* present in the sample.

b) Determining of Free Chlorine Residual

(i) Prepare tubes as outlined above for total chlorine residual, one "blank" tube and one with just a few drops of sample.

(ii) To the tube with sample, add one No. 1 tablet only.

(iii) After disintegration, add water up to mark, and

(iv) Mix as before and match at once. This gives *free chlorine residual.*

Note: It is permissible to determine TOTAL CHLORINE on the same sample by continuing as follows: add one No. 3 tablet, mix and stand for 2 minutes. The colour then read off represents *total chlorine residual.*

c) Determining Combined Chlorine Residual

Total Chlorine Residual - Free Chlorine Residual = Combined Chlorine Residual Value.

2. Nesslerizer

Follow exactly the same procedure for the Comparator, with the following exceptions:

a) Use 50 ml instead of 10 ml.

b) Use special Nesslerizer DPD tablets.

Note: *It must be emphasized that the readings obtained by means of the B.D.H. Lovibond Nesslerizer and disc are only accurate provided that Nesslerizer glass is used which conforms to the specification employed when the discs are calibrated, namely, that the 50 ml calibration mark shall fall at a height of 113 ± 3 mm, measured internally.*

3. <u>False Colour due to Interferences</u>

a) The only interfering substance likely to be present in water is oxidized manganese from potassium permanganate in those water plants that use it for taste and odour control.

b) Test the unchlorinated water for colour development and use as a Blank.

c) *All glassware used must be very thoroughly rinsed after making a test, since only a trace of potassium iodide will cause chloramine colour to develop. Handling the tablets should be avoided. By shaking one tablet into the bottle top it is a simple matter to use the top for conveying the tablet to the Comparator cell or Nessler tube.*

ORTHOTOLIDENE TEST (OT)

General

The orthotolidene test (OT) is used to determine the presence of chlorine residuals in the water. The water is tested for <u>total</u> chlorine residual 15 minutes or longer after chlorination by adding the sample to the OT reagent in a glass tube or glass container. A yellow colour in the sample indicates the presence of a chlorine residual. The deeper the yellow the greater the residual. A lemon yellow colour indicates a safe residual for drinking water.

An approximate free chlorine residual can be determined only when the temperature of the sample is at or very near freezing. The colour caused by free chlorine residuals develops instantly at water temperatures near freezing after the OT reagent is added to the sample. Colour caused by the combined residual develops more slowly, and normally takes up to 5 minutes. The speed of colour development of combined residuals is increased with higher water temperatures.

It is possible that in highly alkaline waters (quite rare in Ontario) a blue tinge may result instead of the yellow colour. This may be corrected by adding an excess amount of OT reagent. Since the reagent is acidic, it will neutralize the excess alkalinity in the water sample. It should be noted that adding too much OT reagent introduces inaccuracies in the residual reading.

The OT method is an old one dating back to 1914, and is still in use in many plants. It has two disadvantages:

1. The super-sensitivity of the chemical causes high intensity colour development so that a chlorine residual cannot be measured accurately above 1 ppm concentration.
2. Free chlorine residual determination only gives an approximate result; ie. you get an idea of its range. The OT method must not be used when an accurate free chlorine residual is required.

To add to this, iron, manganese and nitrites can cause a false colour. The OT method is slowly being replaced by the DPD and the Amperometric methods both of which will be discussed in this workshop.

Procedure for Total Chlorine Residual

1. Pour the required amount of OT reagent into the Nessler tube, Colorimeter cell or other container. Use
   - 0.5 ml OT reagent in 10 ml cell
   - 0.75 ml OT reagent in 15 ml cell
   - 5.0 ml OT reagent in 100 ml cell

   and similar ratios for other volumes.

   Note: *OT reagent should not be kept longer than 6 months. It should be stored in amber-coloured bottles, kept out of direct sunlight and should not be subjected to high or low temperature. Fresh supplies of OT reagent may be obtained free of charge from the M.O.E. Laboratories.*

2. Adjust the temperature of sample to between $15^{o}C$ and $24^{o}C$ (quickly) using warm or cold water.

3. Add sample to the cell or tube up to the mark.

4. Mix solution.

5. About 5 minutes after maximum colour develops, a slight fading begins; therefore, samples containing combined chlorine should be read within 5 minutes and should, preferably, be allowed to develop colour in the dark.

Free Chlorine Residual Test

1. An orthotolidene *flash test* modification for free chlorine residual performed near $1^{o}C$ ($34^{o}F$) or freezing point minimizes the effect of chloramines and their reaction with orthotolidene to produce a yellow colour. Temperature is a critical factor. The sample should be near the freezing point to obtain meaningful results. This is in direct contrast to the OT procedure for combined chlorine residual where the temperature of the sample should be around $20^{o}C$ ($68^{o}F$).

2. Although oxidized manganese affects the test results, slow-acting interfering substances, nitrites and oxidized iron, do not have a significant influence. The flash test has the disadvantage of requiring the *reading of colour within 5 minutes*.

3. *This method is suitable for estimating only.*

4. Procedure for Flash Test

   a) Cool the sample quickly to within one degree of the freezing point.

   b) Add the appropriate amount of orthotolidene reagent that is adequate for the cell or Nessler tube.

   c) Fill the cell or tube up to the mark with the sample.

   d) Place it in the comparator or Nesslerizer and read immediately.

SUBJECT:

CHLORINE TESTING PROCEDURES

TOPIC: 11

AMPEROMETRIC TITRATION

OBJECTIVES:

The trainee will be able to

1. Explain the principle of operation of the Amperometric Titrator.

2. Demonstrate chlorine testing using the Amperometric Titrator.

AMPEROMETRIC TITRATION METHOD

General

The most accurate methods of measuring free and combined chlorine residuals is through oxidation-reduction titration procedures. Such methods require the use of internal indicators or electrometric devices employing a suitable electrode system to show when reactions are completed. Amperometric titrators employing rotating platinum electrodes have been developed for such purposes. See Figure 11-1, page 11-11.

Phenylarsene oxide is the reducing agent normally used as the titrating agent. It reacts with free chlorine residuals at pH 6.5 to 7.5 in a quantitative manner.

By conducting a two-stage titration, with the pH adjusted at about 7 and then at about 4, it is possible to measure separately free chlorine residuals and combined chlorine residuals.

Titrator - Principle of Operation

Titration is a method used to determine the concentration of a substance in a solution. This is accomplished by adding the smallest amount of a reagent (of known concentration) required to cause a neutralizing effect, in reaction with a known volume of the test solution. A graduated vessel (or burette) is used to add the reagent to the known volume of test solution until the chemical reaction between the two is completed. The point of completion is indicated by either (a) adding an indicator dye and watching for a change in its odour or (b) stopping at a predetermined end point on a pH meter or microammeter.

A direct current potential is impressed across two nodal metal electrodes immersed in a measuring cell containing the sample of the solution to be tested. Any

flow of current between the electrodes is directly proportional to the quantity of halogen (such as chlorine, bromine, or iodine) in the sample. The presence of a current is indicated on a microammeter at the top of the instrument.

A reagent (also called a titrant) is added in small doses to the sample, and reacts chemically with the chlorine present in the solution, thereby neutralizing a portion of the chlorine. As more titrant is added, more chlorine is "removed", causing the current flowing between the electrodes to diminish as indicated by the microammeter pointer moving down the scale. Finally, sufficient titrant is added to react with all the chlorine, and no further decrease in current is possible. This is called the *end point.*

The amount of chlorine residual present in the test solution is determined by noting the number of millilitres of titrant used to attain the end point. Then:

mg/l of chlorine = mls of titrant that have been used.

Procedure

1. Filling the Burette

   Make sure the titrant (phenylarsene oxide solution) fills to the zero mark.

2. Titration of Free Chlorine Residual

   a) Fill the solution jar with 200 ml of sample.

   b) Add 1 ml pH 7 buffer solution.

   c) Fill the microburette with the titrant (phenylarsene oxide solution) to the zero mark.

   d) Titrate by adding phenylarsene oxide solution and observe current changes on the microammeter. As long as addition of phenylarsene oxide produces a definite decrease in current, free chlorine residual is present.

e) The end point is just passed when a very small increment of phenylarsene oxide no longer causes a decrease in current.

f) The burette is then read and the last increment of titrating solution is subtracted from the reading to give a value representing the free chlorine residual.

3. Titration of Total Chlorine Residual

a) To the sample remaining from the free chlorine titration add 1 ml potassium iodide solution and then 1 ml pH 4 buffer solution IN THAT ORDER.

b) Titrate with phenylarsene oxide solution to an end point, just as above for the free chlorine residual. It is most convenient NOT to refill the burette but simply to continue the titration.

c) After concluding the titration and having found the end point, subtraction of the last increment again gives the amount of titrating solution actually used in reaction with the chlorine.

d) If the titration was continued without refilling the burette, this figure represents the total chlorine residual. Substracting the free chlorine residual from the total gives the combined chlorine residual, or

Total Chlorine Residual - Free Chlorine Residual = Combined Chlorine Residual

Note: It is essential to wash the apparatus and sample cell thoroughly to remove iodide ion and acetate buffer after this determination, in order to avoid inaccuracies if the titrator is subsequently used for free available chlorine determination.

e) If desired, the determination of the total chlorine residual and the free chlorine residual may be made on separate samples. If only the value for total chlorine residual is required, it is permissible to treat the sample immediately with 1 ml potassium iodide solution followed by 1 ml pH 4 buffer solution. The titration is carried out with phenylarsene oxide solution as described on page 11-3 (2(c)).

Monochloramine and Dichloramine Differentiations

It is often desirable to differentiate between the monochloramine and dichloramine portion of the combined chlorine residual in a sample solution. This differentiation is accomplished in the following manner:

1. Perform the procedure outlined in Procedure for for the Titration of Free Chlorine Residual. Note the reading in ppm (free chlorine).
2. Add 4 to 5 drops of potassium iodide, 5% solution to the sample jar. If monochloramine is present, the ammeter pointer will deflect to the right.
3. Titrate to the "end point"; note the reading in ppm.
4. Add 1 dropper of pH 4 buffer solution and add 1 dropper of potassium iodide, 5% solution to the sample jar. If dichloramine is present, the ammeter pointer will again deflect to the right.
5. Titrate to the "end point"; note the reading in ppm.

The difference between the readings obtained in step 1 ("free" chlorine) and step 3 preceding, represents the monochloramine component.

The difference between the readings obtained in step 3 and step 5 represents the dichloramine component.

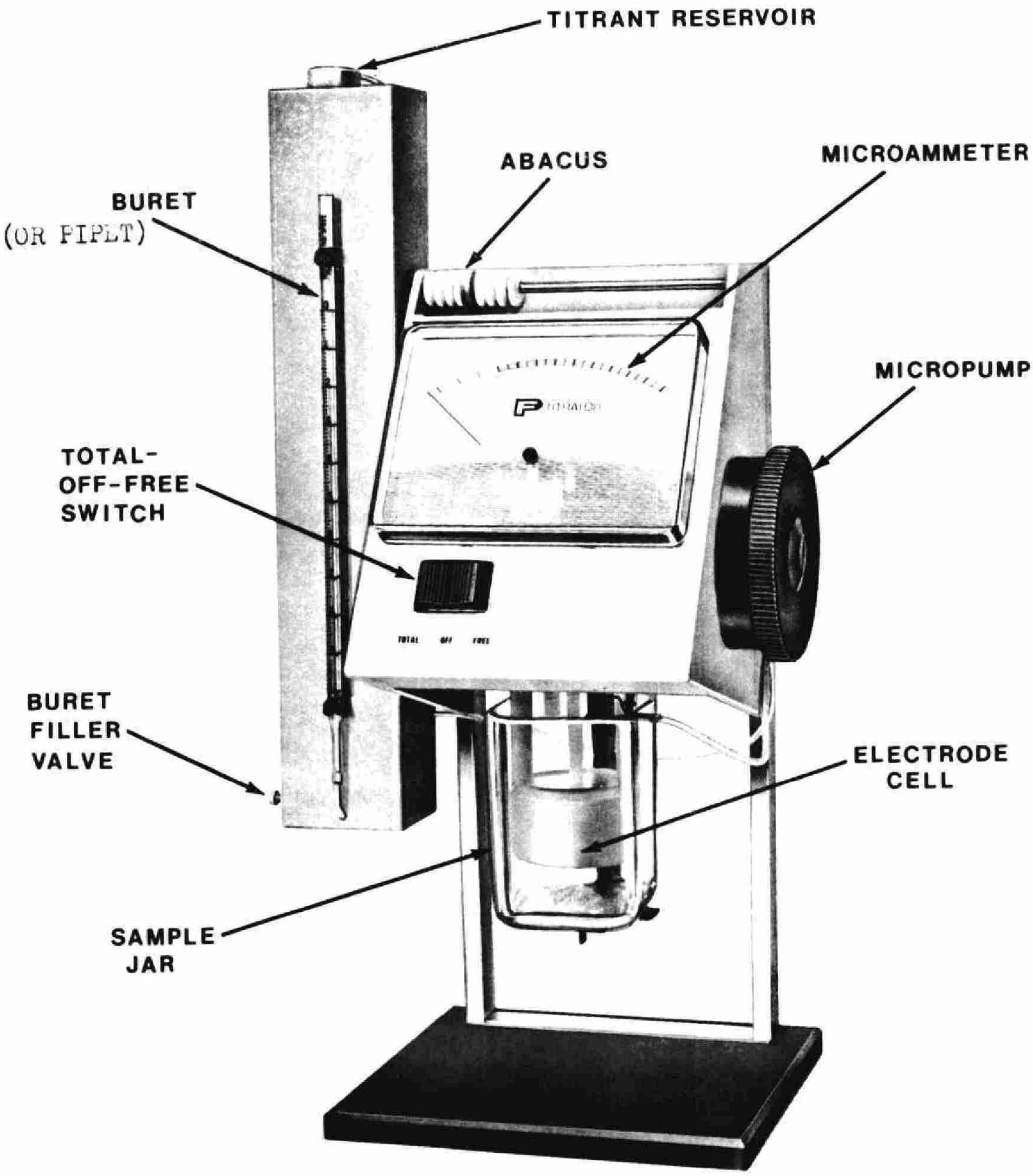

Fig. 11-1 Amperometric Titrator
(Courtesy Fischer & Porter)

GLOSSARY OF TERMS

BREAKPOINT (CHLORINATION)

Point at which near complete oxidation of chloramines and other chlorine combination is reached. Any residual beyond breakpoint is mostly free available chlorine.

CHLORAMINES

Compounds of organic or inorganic nitrogen and chlorine. The reaction of free available chlorine with ammonia and many organic amines to form chloramines, principally monochloramine and dichloramine.

CHLORINATION

The application of a chlorine solution to a water supply or wastewater stream for the principal purpose of reducing population of harmful disease causing bacteria to an acceptable level.

Refer to Bulletin 65-W-4 (see appendix) for details.

CHLORINE DEMAND

The difference between the amount of chlorine added to water or wastewater and the amount of chlorine residual remaining at the end of a specified contact period.

CHLORINE RESIDUAL

Chlorine remaining in water or wastewater at the end of a specified contact period as combined or free chlorine. The chlorine residual for any given water varies with the amount of chlorine applied, time of contact, temperature, pH and the amount of chemical and organic contaminants in the water.

COMBINED CHLORINE RESIDUAL

The chlorine in water in chemical combination with primarily ammonia or other nitrogenous compounds. Combined chlorine residual is measured by taking the difference between Total and Free chlorine residuals.

DECHLORINATION

A deliberate treatment of water to remove excess residual chlorine. Normally done prior to sending water out into system.

DISINFECTION

The reduction of harmful bacterial populations as defined by the Ontario Ministry of the Environment drinking objectives.

FREE CHLORINE RESIDUAL

Amount of chlorine available as hypochlorous acid or hypochlorite ion that is not combined with ammonia or other organic amines. It is much more powerful than combined chlorine residual.

FREE RESIDUAL CHLORINATION

The addition of chlorine to water until the requirements of ammonia and nitrogenous compounds are met plus a slight excess.

NOTE: *This excess will then be in the form of hypochlorous acid which will attack and destroy the chlorinated ammonia and protein substances formed by the initial dose of chlorine. All the resulting residual will consist of 90% or better hypochlorous acid.*

Free residual chlorination is particularly useful where large numbers of bacteria must be killed in a chemically contamined water. It has been clearly demonstrated that it will also inactivate the viruses. This system of chlorination is also noted for colour removal and is effective for the reduction of taste and odours in a raw water supply.

GAS CHLORINATION

Chlorine gas mixed with water to form solution to treat water or wastewater.

HYPOCHLORINATION

The addition of hypochlorites, such as sodium or calcium hypochlorite, to the water or wastewater to be treated. It is added in solution form usually by means of a diaphragm positive displacement pump. Used where chlorine requirement is small or where gas cannot be fed (safety, lack of water pressure).

MARGINAL CHLORINATION

The addition of chlorine to water or wastewater to produce a total chlorine residual in the range of 0.2 to 0.5 mg/l.

OXIDATION - IN TERMS OF TASTE AND ODOUR PROBLEMS

A chemcial breakdown of complex organic compounds used in connection with the destruction of tastes and odours in water.

PARTS PER MILLION

Parts per million (ppm) and milligrams per litre (mg/l) are commonly used terms for expressing concentration in water and wastewater operations. It is a measure of a very small amount of a substance in a very large amount of water. Ppm and mg/l are the same and can be used interchangeably, or

$$1\ mg/l = 1\ ppm$$

PRECHLORINATION

The application of chlorine to a water supply at the beginning of the treatment process.

POSTCHLORINATION

The addition of chlorine to water after turbidity removal.

STERILIZATION

Total destruction of bacterial populations. We never sterilize in the water or wastewater industry.

SUPERCHLORINATION

The application of chlorine to water to provide free residual chlorination. The dosages are greatly in excess of those normally required for normal disinfection purposes but are effective in destroying objectionable taste and odour producing substances.

TOTAL CHLORINE RESIDUAL

Summation of free chlorine residual and combined chlorine residual.

HYPOCHLORINATION

The addition of hypochlorites, such as sodium or calcium hypochlorite, to the water or wastewater to be treated. It is added in solution form usually by means of a diaphragm positive displacement pump. Used where chlorine requirement is small or where gas cannot be fed (safety, lack of water pressure).

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TOTAL CHLORINE RESIDUAL

Summation of free chlorine residual and combined chlorine residual.

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MOE/BAS/GAS/APWN

Date Due

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